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ORBIT OF SIRIUS.

By CHARLES P. HOWARD.

This orbit of Sirius was worked out graphically by the method described in *Astronomy and Astrophysics* for June 1894, to see in the first place, now that the Companion has completed more than a whole revolution in its orbit, whether any indication of perturbed motion would be indicated, as was suspected in the orbit published as an example in the above article, and in the second place to see how accurately an orbit could be worked out by this method.

The conclusions arrived at are, that no disturbed motion is indicated; and that this orbit is about as accurate as the observations admit of, as is proved by the various tests applied to it, described below.

I am indebted to Dr. Aitken for all the observed positions plotted, except the last. He not only sent the measures upon which his orbit was based, published in the Lick Observatory Bulletin, No. 316, September 1918, but also his recent measures. The position for 1919 is based on 2 measures by Aitken and 15 by Barnard.

Without taking space to describe the precautions taken to avoid every source of error, and the niceties of drawing observed, except to say that it was done under a magnifying glass of 3-in. focal length, the various steps taken stated as briefly as possible, were as follows:

The observed annual mean positions, that is the angles reduced for precession to 1920, and the distances, were directly plotted on Bristol board to a scale of 1-2/3 inches to 1 second of arc. Then with an ellipsograph, an ellipse was drawn among them to average all as nearly as possible.

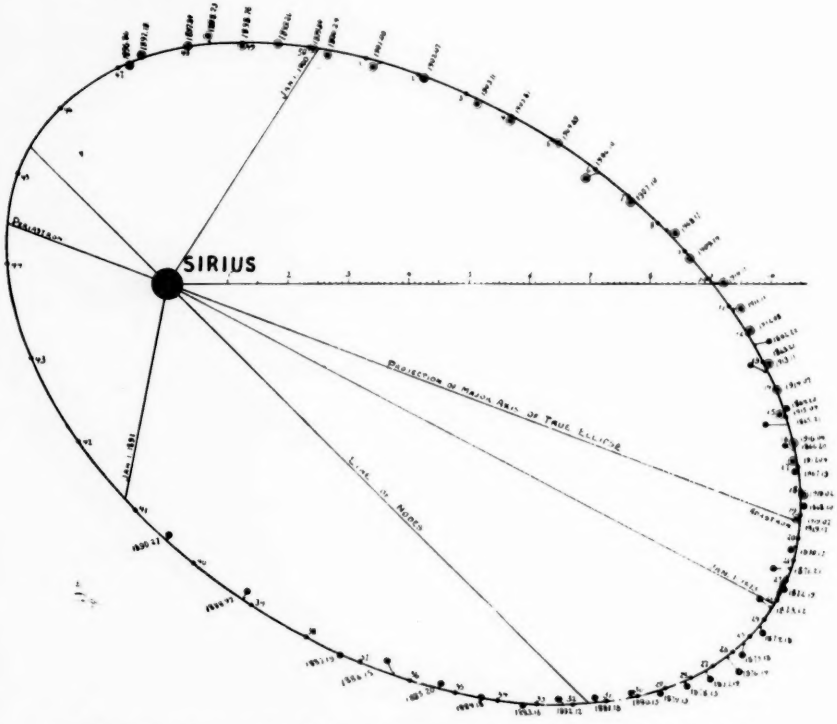
Since the radius vector joining Sirius and the Companion sweeps over equal areas in equal times, it follows that if the period and the position of the Companion upon the ellipse for a single date are fixed, its position on it for every other date is also fixed.

Having decided upon the most probable period and the most probable position of the Companion for some one date, its position for the date of each observed position was worked out graphically and marked on the ellipse. We will call these positions the calculated positions.

Then each observed position was joined by an arrow to each calculated position of the same date; the point of the arrow resting on the latter.

The lengths of the arrows and the directions in which they pointed clearly indicated how this first ellipse should be modified, to give a second, more closely representing the measures.

A second ellipse was then drawn, in the light of the information derived from the criticism of the first, and the position of the Companion for the date of each observed position was determined and marked upon it as before. Then a third ellipse was drawn based on a study of the second, and so on until at the 27th ellipse no further improvement could be made. This is the one shown in the accompanying illustration.



To show how each of the trial ellipses was tested, to determine how it could be modified to better represent the measures, the most important of the tests applied to the final ellipse are given.

The Period.

The period was best determined where the 1862-80 and the 1903-19 series of positions overlap. The period is 50 years plus the fraction of a year represented on the drawing by the interval between the radius

vectors for Jan. 1, 1917, and Jan. 1, 1867. This interval measures 0.169 years, making the period 50.169 years.

The accuracy of the position of these two radius vectors was tested in the following manner:

In the first place it was assumed that because the calculated positions average the observed positions, those observed positions which differ most from the calculated, should have the least weight; and it was further assumed that the observed positions which lie more than 1/10 of a second from their calculated positions, should have a weight inversely as this distance.

All such observed positions therefore were treated as if moved up along the arrows to within 1/10 of a second of their calculated positions; but all lying at or within 1/10 of a second were left as plotted, that is, were all given the same weight.

Unless some such assumption is made, observations that differ most from the average of all, and on that account are the least reliable, have the greatest effect upon the period thus derived.

This test was applied as follows:

For the closest agreement with the observed positions, the calculated positions must be moved along the ellipse in the direction of the Companion's motion, the fractions of a year given below:

Year	Forward	Back	Year	Forward	Back
1862	.05		1903.11		.01
3		.17	3.81	.03	
4	.21		4.89	.06	
5		.04			
6		.16	6		.07
7		.18	7	.02	
8	.20		8	.14	
9		.17	9	.10	
70	.23		10	.12	
1	.12		1	.08	
2	.02		2		.15
3		.03	3	.05	
4	.17		4		.03
5	.20		5		.15
6	.00		6		.01
7	.00		7		.22
8		.05	8	.09	
9		.06	9	.08	
80		.10			
	1.20	.96		.77	.64
	.96			.64	
	19) .24			17) .13	
Average	.013 forward		Average	.008 forward	

This indicates that the radius vector as drawn for Jan. 1, 1867, should be moved forward 0.013 year; and that the radius vector for Jan. 1, 1917, should be moved forward 0.008 year; and therefore that the period should be 0.005 year longer than 50.169 years.

But this correction of less than two days in time, and less than a thousandth of an inch on the drawing, is too small to have any meaning, being below the accuracy of the drawing. The period therefore seems to be close to 50.17 years.

Tested in the same way, this period persisted in all the later trial ellipses, as shown in the following table, which gives the only ones that happened to be preserved:

Ellipse Number	Period as drawn	Radius Vector for Jan. 1, 1867, should be moved	Radius Vector for Jan. 1, 1917, should be moved	Correction to Period	Corrected Period
		Years	Years		
11	50.15	.070 forward	.060 forward	.01	50.16
12	50.16	.015 forward	.005 back	.02	50.18
?	50.18	.010 back	.010 back	.00	50.18
18	50.18	.020 forward	.007 forward	.01	50.19
19	50.18	.010 forward	.005 back	.01	50.19
21	50.18	.002 forward	.017 back	.01	50.17
24	50.18	.006 forward	.006 back	.01	50.17
25	50.18	.006 back	.008 forward	.01	50.17
27	50.17	.013 forward	.008 forward	.00	50.17

The third and fourth columns show how accurately these two radius vectors were located with reference to the observed positions in all the ellipses after the 11th, and on the above assumption of weights how close the period must be to 50.17 years.

The Major Axis.

The major axis of the apparent ellipse was tested by using the same assumption as in determining the period. The observed positions fall inside or outside of the ellipse as follows, in fractions of a second of arc.

Years	Inside	Outside	Years	Inside	Outside
1862		0.10	1906	0.09	
3	0.07		7	.05	
4		.05	8		.05
5	.10		9	.03	
6	.08		10		.08
7	.06		1		.09
8		.05	2		.07
9	.06		3		.08
70	.08		4		.02
1	.09		5	.09	
2		.03	6	.00	
3	.10		7	.07	
4		.10	8		.04
5		.07	9	.06	
6		.10			
7		.10		.39	.43
8		.10		.87	.81
9		.07			
80	.07			1.26	1.24
1	.08			1.24	
2	.08				
3		.04		36) .02	
	.87	.81		Average = 0.0006 Inside	

The ellipse therefore averages the distance as nearly as possible.

The general accuracy of the final ellipse was tested as follows:

The major axis of the true ellipse was found by drawing a straight line through Sirius and the center of the apparent ellipse. The minor axis of the true ellipse was found by bisecting six chords near each end, drawn parallel to the major axis. These twelve points all lay in a straight line, passing through the center of the ellipse.

Then according to the calculated positions the Companion passed

	Year	Interval	
The apastron	1869.16		
		17.32	
The Minor axis	1886.48		25.09
		7.77	
The periastron	1894.25		
		7.78	
The Minor axis	1902.03		25.08
		17.30	
The apastron	1919.33		
			50.17

The first and last intervals should be equal; and also the second and third. When it is remembered that a hundredth of a year is only three and a half days, it certainly inspires confidence in this orbit to have it stand this test so well.

The final and most severe test was the following, the above assumption as to weights being observed:

Each calculated position angle was subtracted from each observed angle, and each calculated distance from each observed distance.

These differences were added together and divided by the total number of positions, to find the average difference, thus:

SUM OF THE O - C's

	Angles	Distances
Sum of the plus quantities only	+ 7°.51	+ 1".52
Sum of the minus quantities only	— 9.35	— 2.12
Sum	— 1.84	— 0.64
Dividing by 55 gives an average of	— .033	— .012
A shift of ½ the average should be made to correct	— .016	— .006

These corrections are too small to have any real significance and this ellipse cannot be further improved.

Burnham said in 1891, that within somewhat narrow limits any number of orbits would represent the measures equally well. With the measures now to be had, these limits are very narrow but still perceptible, and it will be many years before an extremely accurate orbit can possibly be derived. An orbit however to stand the above tests must be pretty close to the true one.

ELEMENTS OF SIRIUS.

Period in years	50.17
Periastron passage	1894.25
Eccentricity	0.5938
Semi-axis Major	7".482
Inclination	42°.01
Position of Periastron	148°.38
Position of Nodal Point	44°.56

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THE FRICTION OF THE GYROSCOPE: HOW TO ELIMINATE IT.

BY M. C. MOTT-SMITH.

In the ordinary text-books the theory of the gyroscope is developed on the assumptions that there are no frictions and that the supporting mechanism has no weight. The propositions so derived are then frequently illustrated by experiments in which the behavior of the gyroscope is described as though everything took place exactly in accordance with the theory. Only now and then is the reader warned, (oftentimes only in a foot-note), that friction may produce some slight modifications. If one repeats the experiments with an ordinary instrument, he will find not only slight modifications, but oftentimes behavior is so totally different from that called for by the theory, as to justify doubts as to the correctness or completeness of the latter. One must often wonder whether the authors of these texts really ever performed the experiments they describe. Where the divergency between theory and fact is so great, as in the case of the gyroscope, it certainly should not be dismissed with a vague remark or two about friction. While the theorist may care little about it, the practical man naturally wants to know why the actual gyroscope behaves as it does. His curiosity on this point should be satisfied—and that is what the present investigation aims to do.

We shall study the behavior of an actual instrument to find out its causes—what part is due to friction or other defects, what part to true gyroscopic causes. We shall then show methods by which the frictions and other defects may be removed or their effects annulled; the behavior of the actual gyroscope thus made to coincide with what theory tells us it really ought to do, but which it generally doesn't. So far as I know, this has not been done before. The matter is of importance in astronomy because the planets are gyroscopes, and are subject to tidal frictions.

Fig. 1 shows the kind of instrument that should be used. The wheel, W, is supported by three rings, which we shall call the x, y, and z rings as marked, the x ring being innermost. We accordingly

have the x, y, and z axes, the x and x' bearings, etc., carried by the corresponding rings. The x axis is the spin axis or axle of the wheel. We also have the x, y, and z frictions respectively. The outermost or z ring is usually fixed in position by the clamp screw Z, so that it merely forms part of the frame of the instrument. Accordingly the z axis is vertical and fixed. It has no freedoms. The y axis is always

Fig. 1

horizontal, but can turn in azimuth, as the y ring turns in the z bearings. It therefore has one freedom. The x axis can turn in azimuth as the y ring is rotated, but it can also turn vertically about the y bearings. It can therefore be set in any direction, and has two freedoms. Finally the wheel of course has three freedoms. It is to be noted that the x, y, and z axes, as here described, are not the usual fixed coördinate axes. They have been chosen in this way merely for convenience of description. Since there will be no mathematical treatment, coördinate axes are not necessary.

Any change in direction of the axle, that takes place while the wheel is spinning, will be called a precession. It is to be noted that whatever the direction of such precession, the motions of the x and y rings, by construction of the instrument, show at once its vertical and horizontal components respectively, except when the axle is vertical. In the latter case the y ring may rotate rapidly, but shows no precession for there is none. It is merely dragged around by the x friction.

In common forms of gyroscope the outer or z ring is frequently omitted, and the y ring even reduced to a fork. The z bearings are then replaced by the vertical spindle at the lowest point of the y ring, which is allowed to turn in the socket at the top of the stand. In this form the z friction is excessive, and since this, as we shall see later, is the most important of the frictions, this form should be avoided.

The weight of the rings has two effects, which may be called inertial and static. The former occurs only when there is a change in the rate of a precessional motion, which requires a torque to produce it. In the weightless theory, only the inertia of the wheel is taken into account. We have merely to correct this by adding the inertia of the x ring, when the precession is vertical, and the inertias of the x and y rings, when the precession is horizontal. This is but a small correction to an effect already so small as to be seldom observable, and which moreover does not occur when the precession is steady. Hence it is truly negligible, and need not concern us at present.

The static effect occurs when a ring is out of balance. If one end of the x ring is heavier than the other, then when the wheel is stationary, the former end will sink, carrying with it the axle. When the wheel is spinning, this torque will cause a precession. To avoid this the ring must be balanced, either by attaching small weights to the lighter end, or by removing some of the metal from the heavier end. It is not sufficient however to balance so that the axle will stay in any position in which it is put. When that is accomplished, it simply means that the remaining unbalance is insufficient to overcome the static friction of the bearings. But kinetic friction is less than static. The final tests should be made by spinning the wheel with the axle horizontal, and correcting the balance until there is no precession during the whole course of the spin. The final stages should be watched particularly carefully, for the precessions increase when the spin is low. The wheel should stop in precisely the same position in which it started. To secure this may require some hours' labor, but it is of great importance in no-precession experiments.

So long as the z axis is strictly vertical, the y ring need not be balanced. But it is well to do so anyway, by turning the z axis horizontal, and balancing the y ring in the same manner as was done for the x ring.

We shall now by a series of experiments determine the effects of the three frictions. We shall take them up separately in the order z, y, x, which is the order of their importance.

THE z FRICTION.

Experiment 1. The Precession.

Give the wheel a counter-clockwise spin, with the axle horizontal and pointing toward the observer, as in Fig. 2. Attach a small weight

w, by means of a bit of wax, to the nearer side of the x ring. This is better than suspending a weight, since the suspension would soon interfere with the ensuing motions.

As soon as the instrument is released, the near end of the axle instead of falling directly downward under the weight, as it would if there were no spin, moves horizontally to the right, as shown by the arrow in the figure. This is the well known precession. The frictionless theory tells us that whenever a torque is applied to a spinning wheel, precession occurs about an axis perpendicular to both the torque and spin axes, and the spin axis turns toward the torque axis, so that if the two ever came into coincidence, spin and torque would be in the same sense. Also when the spin is low the precession is greater. The *only* effect such a torque, when the steady state is reached, is to maintain this precession about the perpendicular axis.

Fig. 2

In the present case then, according to the theory, the axle should continue to rotate in a horizontal plane. But observing carefully, we note that the weighted end of the axle is gradually sinking. As the spin diminishes both the precession and the sinking increase in speed, so that the end of the axle winds spirally inward and downward until it reaches the nadir. The final outcome is hence the same whether the wheel is spinning or not, only in the former case it takes a longer time and a more circuitous route to get there.

We have all witnessed similar phenomena when a fine pegged top is spun in an inclined position. The head of the top describes a horizontal circle. But as the spin diminishes, the top gradually sinks, until it finally strikes the ground.

It is natural to attribute this sinking of the axle to the dying out of

the spin. Is it not the spin that holds the axle up? Would it not fall immediately if there were no spin? Does it not resist all the more sturdily, the greater the spin? What then more natural than to suppose that as the spin dies down it becomes less and less able to "overcome gravity"? This is in fact the popular conception. But it is entirely at variance with our frictionless theory. The latter asserts that the torque of the weight produces a *horizontal* rotation of the axle. Having produced this effect, it can produce no other, last of all a second rotation perpendicular to the first one. There is no provision in this theory for a steady downward motion of the axle, such as always occurs. To explain this gyroscopically requires a torque about the z axis, opposed to the horizontal precession. We have just such a torque in the z friction. According to our theory then the sinking of the axle is not a gradual succumbing to the force of gravity. It is a second precession induced by the torque of the z friction. It follows, that if z friction could be entirely removed, the axle would precess strictly horizontally despite the down pressure of the weight, *however low the spin*. The deduction seems incredible. Yet it is precisely what we intend to show.

The more usual methods of studying the effects of the z friction are three in number as follows:

EXPERIMENT 2. Application of a z Torque.

While the gyroscope is spinning and precessing as in experiment 1, lightly oppose the motion of the y ring with the finger. The downward motion of the axle at once increases, the more so the greater the opposition. Now press lightly on the y ring in the direction in which it is turning. The downward motion of the axle diminishes. With greater pressure, it ceases, and with still greater, the axle will rise. Hence we get the familiar rule: "Hurry the precession, and the top rises." The two experiments show that a torque about the z axis will produce the required vertical precession. Finally stick a pencil against the fixed z ring, in such a way that the y ring in turning will hit against it, and so be stopped completely. The axle falls at once, with the same alacrity as when there is no spin. Obviously it is not the spin that holds the axle up, but the precession. Prevent precession, and no possible spin will sustain the smallest weight. The so-called gyroscopic resistance vanishes completely. We have also seen that any opposition to the precession diminishes the gyroscopic resistance in proportion to the opposition. We may again draw the conclusion, that if the precession were completely unopposed, the axle would not sink at all.

EXPERIMENT 3. Increasing the z Friction.

Spin the gyroscope as before, but slightly tighten the z bearings so as to cause them to bind somewhat. It will be found that the sinking has increased. Since the rate of both precessions will depend upon

the rate of the spin, and this cannot be exactly duplicated, it is the ratio of the two precessions that we must observe in this experiment, say the amount of horizontal turning accomplished, before w reaches the nadir. This will be found for the same w, to be fairly independent of the rate of spin.

Now tighten the z bearing somewhat more. The sinking will be further increased. Proceed in this way by gradual steps until finally the z bearing is clamped. The axle on being released now drops at once. It can in fact be turned over and over or spun vertically, with no more resistance than that offered by the friction of its bearings. The spin of the wheel causes no resistance. The effort to precess is however so great that unless the z bearings are very tight they may give way. There is always a groaning sound in this experiment. The popular notion that a gyroscope objects to having its spin axis turned is inexact. What the gyroscope decidedly objects to, is any interference with its precession. The axle may easily be turned in any desired direction by applying the proper torque. But stop the precession and the internal strains suffered are immediately evidenced by the groans emitted.

EXPERIMENT 4. Diminishing the z Friction.

If in experiment 3 we began with well oiled and adjusted bearings, so that they were already in the best possible condition, we cannot reduce friction by any further improvement of them. But we can easily do so in another way. Take the instrument out of the z bearings, and suspend it by a long thin untwisted fibre, the lower end attached to the top of the y ring, the upper end to a fixed support. It will require several hours to get all the twist out of the suspension, so that it is best to hang the instrument up the night before, and perform the experiments next morning. If now experiment 1 is repeated, it will be found that for a long time there is not the slightest perceptible sinking of the axle, while the whole instrument rotates continuously about the vertical axis. Finally a slight sag will appear, which once started increases much more rapidly than in experiment 1, so that the final descent to the nadir is fairly quick. But when this point is reached, it will be found that the wheel has either completely stopped spinning, or at most continues for but two or three turns more. Meanwhile the rotation of the whole instrument about the vertical continues by its momentum, but finally is brought to rest by the torsion of the suspension. Then it begins to rotate in the opposite direction as the fibre untwists. If it is desired to repeat the experiment, the number of turns made during the twisting up process should be counted, and the instrument stopped, when it has untwisted the same number. The equilibrium position of no twist can then be found in a few minutes by proper tests. Otherwise the instrument will go on and twist up in the opposite direction, nearly as many turns as the first twist, and so

twisting and untwisting will again require several hours to come to complete rest.

In this experiment resistance to precession has been reduced to an extremely small amount, and we see that it ***almost*** accomplishes what the frictionless theory demands, namely, the axle remains horizontal *almost* to the end of the spin. We shall now in the next experiment, fully comply with the theoretical conditions entirely.

EXPERIMENT 5. Removal of z Friction.

Replace the instrument in its usual z bearings. Now so long as the y ring turns in these bearings, its motion will be resisted by their friction. If we could destroy the relative motion of the y and z rings there would be no friction between them. This can easily be done in the following manner. Loosen the lowermost screw Z, Fig. 2, which clamps the z ring. Now spin as before, starting with the y and z rings exactly in one plane. At the moment of releasing the axle grasp the z ring, being careful not to touch any other part of the instrument, and turn it smoothly and evenly so as to keep exact pace with the y ring, as the latter precesses. In the instrument shown in the figures, the rings being rectangular in section, this can be done with great nicety. It will now be found that the axle remains strictly horizontal thruout the *whole course of the spin.* At the end it drops suddenly, just as though it had rolled off the edge of a table. The spin will then be found to be completely dead.

So effective is this method, that even with the very slight spin that can be communicated to the wheel by means of the fingers, the axle will remain horizontal to the *end* of the spin, provided the much more rapid precession then occurring can be properly followed with the z ring.

In this way it is shown that the frictionless theory is strictly true, not only for planets and molecules that have no axles or bearings, but also for the ordinary gyroscope. If the theory breaks down anywhere, it is not until the last fraction of a turn.

There is another way in which precessional resistance might presumably be annulled, but the result is quite different from what might be expected.

EXPERIMENT 6. Back-Twisted Fibre.

The gyroscope is to be again suspended as in experiment 4, and that experiment repeated, counting the number of precessional turns made up to moment that w reaches the nadir. At this moment the twirling is to be stopped, the instrument allowed to untwist, and then twist up backwards, one half the number of turns, that were made forwards by the precession. At this point it is again stopped, the wheel given as nearly as possible the same spin as before, and the instrument released. It is obvious that if the same number of precessional turns are again made as before, during the first half of

them, the fibre will be untwisting, and so aiding the precession, while during the last half, it will be twisting up and so hindering precession. The aid and the hindrance will be substantially of equal amounts, so that the net result should be zero. We might expect the axle to rise a bit during the first half, and then sink to its original level at the end of the second half. But instead an astonishing thing happens. For a long time nothing happens. The instrument precesses steadily, with no observable departure of the axle from the horizontal. But when about three-quarters of the turns are completed, the axle is seen to be *rising*. The motion slow at first, rapidly increases in speed, until w reaches the *zenith*. There it hesitates a moment until the spin is almost dead, when it falls to the nadir.

This behavior is in accord neither with popular conceptions, nor with the frictionless theory of the text books, nor with the z friction theory we have laid down. It is a striking illustration of the truth of the remark made at the beginning, that the frictions are not always mere slight disturbances. They are at times quite the determining factors. The explanation of this remarkable behavior must be deferred until after we have studied the other frictions.

Another line of investigation leads to the same conclusions concerning z friction, and yields some further information of importance concerning it.

EXPERIMENT 7. The Nutation.

The gyroscope is again to be suspended, so that precessional resistance is reduced to a minimum. Give the wheel a small spin, with horizontal axle, but no weight. Provide a rather large weight with a hook, and suddenly hook it on the end of the axle. If the spin is not too great, it will be noticed that the axle dips, and executes a series of vertical oscillations of diminishing amplitude, finally settling down at a somewhat lower level than that from which it started. Also the precession started immediately, but proceeded jerkily at first. But the jerks died out at the same time the vertical oscillations did, after which the precession proceeded steadily. Now suddenly remove the weight. The axle immediately rises above its original level, sinks again, and after a number of oscillations settles down at about the original level. The precession meanwhile, after a few concomitant jerks, stops. The experiment may perhaps be repeated two or three times before the spin is dead, and will show that the less the spin, the greater are these oscillations. If the spin is very low, the first dip may be so great that the axle cannot recover before the spin is dead. Thus a top must have a certain minimum spin in order to stand up at all. This is the speed at which the side of the top would just not strike the ground on the first dip. This dipping is called the nutation.

At ordinary speeds the nutation is too slight to be observed. It may be made visible however, if the spin is not too high, by allowing a beam of sunlight to fall upon the gyroscope. A number of curious

reflections will be seen upon the walls of the room. By wiggling first the x, then the y rings, suitable spots or streaks derived from these rings may be selected for observation. Then when the weight is applied these spots will be seen to quiver as they move forward. With higher speeds the images will simply be blurred at first, and later become sharp.

The experiment may be varied by suspending the weight by a thin strip of rubber, or by a light spiral spring, and causing it to oscillate up and down. In this way are simulated the forced nutations, which the earth undergoes, because of the periodically varying torque, exerted by the attractions of the sun and moon upon her equatorial protuberance.

These nutations that occur when the speed of precession is changed, appear to contradict the principle already laid down that a torque produces a precession about a perpendicular axis. But it must be remembered that this is strictly true only when the precession is entirely unhindered. When the weight is first applied there is *no* precession. Therefore the axle starts straight downward, as in the latter part of experiment 3. Precession begins at once but is hindered by the inertia of the rings and wheel. Hence at this stage w moves slantingly as in the middle part of experiment 3. As the precession gathers speed, the inertial resistance diminishes, w moves more nearly horizontally, until finally the precession acquires a surplus speed and is carried forward by its momentum. Then the axle rises, for the precession is hurried. (See exper. 2.)

To start precession requires an expenditure of energy, and this is derived from the sinking weight. But like a pendulum it shoots beyond the equilibrium point, and has to return. There is therefore a flow of energy back and forth, until the precession settles down to the steady state, at a slightly lower level. The difference between the original and final levels of w, measures the energy represented by the steady precession. This state once attained requires, in the absence of frictions, no further expenditure of energy to maintain it. Hence the weight sinks no more, but continues to revolve steadily at the new level.

We may now see why when z friction is present the axle must sink steadily. Part of the energy which the dip puts into the precession is absorbed by the z friction. This consumption continues steadily, hence w must sink steadily to supply it, just as a locomotive must not only start a train, but must pull steadily to supply the energy consumed by friction. The sinking is hence in reality a continued dip.

We also see why in this experiment, z resistance must be reduced to a minimum, for otherwise, like a strongly damped pendulum, the oscillations will be unobservable, and may even be absent altogether.

EXPERIMENT 8. The Revolved Gyroscope and Planetary Inversion.

The gyroscope, replaced in its ordinary bearings is now to be

fastened to the end of a rotating arm as in Fig. 3, spun with horizontal axle, and revolved. It will now be found, that even though perfectly balanced and no weight applied, one end of the axle slowly rises until the axle stands vertical, with the spin in the same sense as the revolution. Further turning produces no further effect, but if the revolution be reversed, the axle slowly turns over in the reverse sense until it again stands vertical with the up side down, and there remains as the revolution continues. This motion will be called the inversion. It will be noted that the gyroscope in this experiment simulates the situation and action of a planet revolving about the sun. We shall accordingly use the terms "direct" and "retrograde" in their usual astronomical sense.

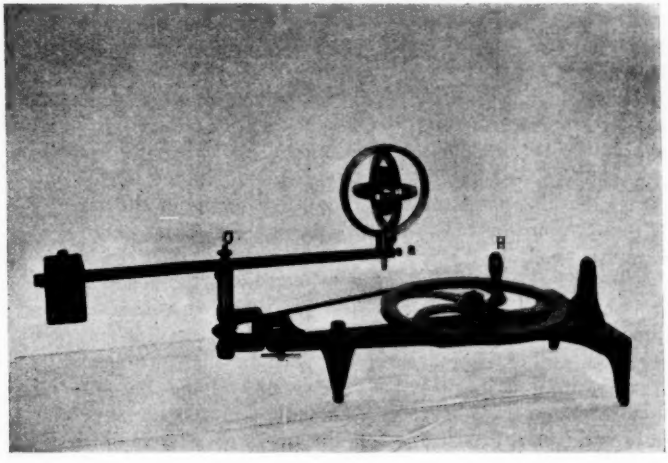


Fig. 3

It has been thought by Pickering[1] and others, that the planets have undergone a similar inversion—that originally they all had retrograde rotations, but that in the course of time the axes have gradually turned over until now nearly all have direct rotations.

Besides the inversion, there is also a horizontal precession to be observed in this experiment. The *y* ring at first maintains its plane substantially parallel to itself as it revolves. But gradually it turns slightly in the same sense as the revolution. When the axle finally stands vertical, the *y* ring may rotate rapidly, but this is no longer a precession, according to our definition, for there is then no change in direction of the axle. The *y* ring is then simply dragged around by the friction of the axle.

[1] "Astronomy and Astro-Physics," June and Sept. 1893.
"Popular Astronomy," Oct. 1917.

The inversion of the gyroscope is correctly attributed by Pickering to z friction, and in the case of the planets he supposes a similar resistance to be offered by an "annual tide."[2] In fact we may note, that the z ring being securely fastened to the end of the revolving arm, is forced to rotate with it, at the same speed. It therefore exerts a frictional torque upon the inner parts of the apparatus, in the same sense as the revolution. In fact if the apparatus be revolved slowly and evenly without spin, the inner parts also rotate with the z ring as one piece, though there is no connection between them except through the z bearings. But if the arm be given a sudden twist, the inner parts remain behind, showing that it is really z friction that turned them in the first case. If now the wheel be spinning, the y ring maintains its direction in space but little altered, while the z ring rotates around it. But now, instead of dragging it with it, the frictional torque of the z ring produces a vertical precession in accordance with the principles already laid down.

We may imagine the gyroscope to be slid along the arm toward the center O (Fig. 3.), and fastened at various points. In every case the z rotation is equal to the revolution. But when the gyroscope is fastened at O, it is rotated only. By a series of experiments, with the gyroscope alternately at the end, and at the middle of the arm, we may show that the phenomena in the two cases are in every detail the same, and are due solely to the rotation of the z ring. That the inversion is really due to z friction can then be proved by methods similar to those of experiments 2, 3, 4. and 5. First, we may, with non-revolving instruments, push on the y ring in the direction in which it was previously revolved, and show that inversion can be thus produced, while a contrary push will produce an inverse inversion. Second, we may gradually tighten the z bearings, and show that at each stage inversion is more rapid, until at last when the bearings are clamped, it takes place at once upon attempting to rotate or revolve the instrument Third, we may suspend the gyroscope from the end of the revolving arm by a long fibre, and show that inversion is then much reduced. Fourth, we may eliminate z friction, in a manner to be described later.

THE y FRICTION.

The slight horizontal precession that takes place in these experiments looks as though the y ring were dragged to some extent by the z friction. But this is not so. It is a nutation, similar to the initial dip, and continued dip, that occurred in experiment 1, and due to similar causes. To produce this precession we require according to our principles a torque about the y axis opposed to the inversion. The y friction offers such a torque. In fact, if while inversion is proceeding, we place a small weight on the end of the axle which is rising, the horizontal precession will be increased. If we put the weight on

[2] Ibid.

the other end, the precession will be diminished, annulled, or even reversed, according to the size of the weight, while inversion continues in the same direction. On the other hand by gradually tightening the z bearing, we may show that the relative amounts of the horizontal and vertical precessions are unaffected by this tightening, even though the z bearing be clamped. In this latter case inversion takes place at once, but the amount of horizontal precession accompanying, say one-quarter of an inversional turn, is precisely the same as when the z bearing is entirely free. When clamped, the whole instrument must of course turn the required amount, with the y ring. The horizontal precession is therefore not affected by the z friction.

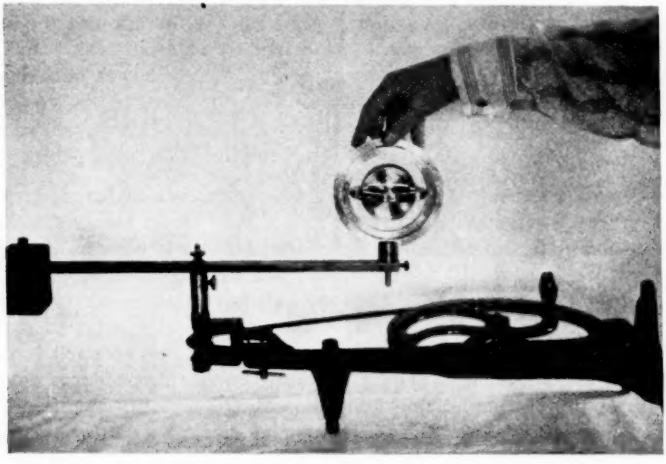


Fig. 4

On the other hand by gradually tightening the y bearings, we find at each stage, the precession for the same amount of inversion is increased, until at last when these bearings are clamped, the y ring turns as one piece with the z ring, precisely as though the z bearings were clamped.

In fact by properly adjusting the two sets of bearings we can get any desired ratio of the two precessions, limited only by the minimum friction attainable. To do this, we must always, so to speak, tighten the wrong bearings to get the right result.

EXPERIMENT 9. Removal of z Friction in the Revolved Gyroscope.

We have seen that the precessions of the revolved gyroscope are due to the rotation of the z ring, z friction producing the vertical, y friction the horizontal precession. Therefore if the z ring is prevented from rotating, while it revolves, both precessions should disappear. This might be accomplished by a mechanical device, but in practice it

is found that the simple method shown in Fig. 4 is sufficient. The clamp screw at *a* is loosened, the wheel is spun with axle horizontal, and the *y* and *z* rings are set coplanar. Then instead of revolving by turning the handle, the *z* ring is grasped as shown in the figure, and the instrument pushed round and round, while the *z* ring is held so that its plane is always parallel to itself. In short it is revolved without rotating. It will now be found that whatever the ratio or direction of spin or of revolution, the direction of the axle shows no change throughout the whole course of the spin, or even thereafter. The *y* and *z* rings remain coplanar as at the start. In fact the instrument may be taken off the rotator, and moved about in any manner whatever, so long as the *z* ring is kept always parallel to itself, and the *z* axis vertical, without any change whatever in the direction of the axle. For the gyroscope such a motion does not differ from rest. But the moment the *z* ring is allowed to rotate, both precessions at once begin. They are therefore entirely due to this rotation.

THE *x* FRICTION.

In testing the balance, and in all the experiments so far described, it has always been specified that the axle should be set horizontal. This was to eliminate the effects of the *x* friction. It is obvious that this friction, besides diminishing the spin, tends to drag the *x* ring around in the direction of the spin. When the axle is vertical, as at the end of experiment 8, this friction in fact causes the *x* and *y* rings to rotate with the wheel. But when the axle is horizontal this rotation is prevented by the *y* bearings. The *x* friction then merely produces an upward pressure on one bearing and a downward pressure on the other. In any inclined position, the torque of the *x* friction can be resolved into two components, one horizontal the other vertical. The former will merely produce pressures in the *y* bearings, but the latter will coincide with the *z* axis, and produce precessions similar to those produced by the *z* friction. In fact, if in experiment 8 the axle is inclined upward, so that the spin is direct, but the apparatus is not revolved, both precessions will be found going on slowly by themselves, in the same direction as when the apparatus is given a direct revolution. If the axle is inclined downward, both precessions are reversed in the stationary gyroscope. Both precessions increase as the axle approaches the vertical, for the vertical component of the *x* frictional torque then increases.

With good bearings, these spontaneous precessions are very slight. Still they would entirely vitiate any no-precession experiment like number 9. That they are really due to *x* friction can be proved by the same methods as before. We may apply a torque to the *x* ring in the direction of the spin, or contrary, when the spontaneous precessions will be increased or diminished respectively. We may increase the friction by tightening the *x* bearings, but this is inadvisable, as

these bearings are already subject to much wear. A better way is to provide a light paper brake as shown in Fig. 5. By varying the pressure of this brake, the spontaneous precessions will be found to vary in like manner. Naturally x friction cannot be very much increased, or the spin will die out so rapidly, that no observations can be made.

Fig. 5

It is interesting with this brake to repeat experiment 8, with the axle inclined sharply downward. If conditions are properly adjusted, then despite a forward revolution, the axle will precess downward, and retrograde, and stand vertical with the spin in the opposite sense to the revolution. This of course is directly opposite to the usual result of this experiment.

Finally we may annul x friction by driving the wheel with a motor attached to the x ring. Such a motor presses back on the x ring with a force precisely equal to that with which the friction of the axle tries to drag the x ring around, so long as the speed is constant. Of course when the motor is accelerating, the x ring must be held, or the axle set horizontal, since otherwise the x ring will be driven backwards. If one is so fortunate as to possess such a motor-driven gyroscope he may repeat with an inclined axle all the experiments for which we have here specified a horizontal axle and enjoy also the advantage of a higher and a constant spin.

When the axle is inclined upward, x friction carries it further upward, and when it is inclined downward, x friction carries it further downward. Hence the horizontal position is one of unstable equilibrium in this regard. If there is any slight displacement, x friction will increase the displacement. This explains the anomalous behavior of the suspended gyroscope in experiment 6, in which we endeavored to annul the precessional resistance,by twisting the fibre backwards half as many turns as we expected to be made forwards. In untwist-

ing, the torsion of the fibre aided precession, and so raised the axle slightly, as we expected. But when the fibre began to twist up, instead of restoring the axle to its original level, x friction had already obtained a grip, and proved to be stronger than the very feeble torsion of the twisting fibre. As the axle rose, the z component increased, so that soon the fibre was completely out of the running, and the course of the experiment was exactly opposite to that expected. We had reckoned without x friction. With the gyroscope mounted in the usual way, the instability of the horizontal axle is not in evidence. But in this case, with z resistance reduced to an extreme minimum, it became quite the determining factor.

All this goes to show that we must take strict account of all the frictions, if we are successfully to predict, or correctly to understand, the behavior of an actual gyroscope under all circumstances. The behavior may be entirely different from, and even contradictory to, that deduced from the frictionless theory. The axle may go up, or it may go down, though theory says it should stay in the middle. In fact, the gyroscope has no manners. The only frictionless gyroscopes are planets and molecules, which are without axles and bearings. All others misbehave in various ways, for which we must learn to make the proper allowances. In the ordinary gyroscope the precessional effects of all the frictions may be removed by setting the axle horizontal, and destroying the relative motion of the y and z rings, either by moving the latter as in experiment 5, or by stopping its motion as in experiment 9. In the motor gyroscope, so long as the speed is constant, only the second condition is required. By observing these two simple rules, any ordinary gyroscope may be made to behave itself as it theoretically ought to.

AN OBSERVATORY ON THE EQUATOR.

By JAMES H. WORTHINGTON.

The study of Planetary Astronomy is prosecuted mainly by private enterprise. Most observers—situated as they are in comparatively high northern latitudes—have only been able to study the planets at locally favorable oppositions (or elongations). For example; Mars, during the opposition of the present year, is so far south as to be inaccessible to useful scrutiny from any observatory in Europe—and most of those in the United States.

And yet planets, being the only possible, probable or certain abodes of life, are more interesting to ordinary people than any other bodies in the heavens.

The planets move in the Zodiac, and zenith observations of them—which are best—have almost never been made, being only possible in the tropics.

It seems highly desirable that an observatory be founded for this study in the best site the earth affords. Such an observatory should be on the equator—as high above sea level as possible—and accessible from all parts of the earth.

The present time is the more opportune for the founding of an equatorial observatory, as Jupiter is now, and will remain, in southern declination until 1931. Saturn will not return North until 1937. Uranus is still south of the equator. Neptune alone is—and for a long time will be—really well placed for the majority of observers in the Northern Hemisphere. I here assume that only those oppositions where a planet's meridian altitude exceeds 45° may be considered locally favorable. In 1924 Neptune alone is so placed for observers north of the fortieth parallel. This excludes the vast majority of observatories in both the New and Old Worlds.

The British Nautical Almanack lists 153 observatories. Of these only seven are 4000 or more feet above sea level. Of these seven, three only are in the tropics. They are:

Arequipa, Peru	Lat. 16° South. Alt. 8000 feet.
Kodaikanal, India	Lat. 10° North. Alt. 7700 feet.
Tacubaya, Mexico	Lat. 19° North. Alt. 7600 feet.

None of them are equipped for—or engaged in—extensive planetary work.

Following the equator round the world we see that there is only one possible observatory site which combines the three desiderata of

Altitude—Over 9500 feet.
Latitude—Quito, Lat. 0°. City 14 miles south.
Accessibility—Rail from Guayaquil, 200 miles.
Steamers from Panama, 700 miles—2 days.

An observatory near Quito could be placed exactly on the equator. Higher above sea than any other astronomical station. Accessible by sea, via Panama, from America, East and West; also, by direct steamer, from Europe and Australia. Climate not tropical—40° to 75° F. Rain moderate—two seasons, 50in. Population—60,000. Civilized conditions.

This site excels all others on earth for the following branches of research:

a. All planetary work.
b. Observation of Moon and Comets near the Sun.
c. The Galaxy and all photometric comparisons between stars in similar declinations in both Hemispheres. From this latitude alone the whole sky is visible. Duration of twilight is a minimum.
d. Observations of Zodiacal Light and Gegenschein.
e. The search for possible minute bodies close to the sun.
f. The search for minute meteoric satellites of the earth—on which a few remarks are offered in this paper.

It is generally agreed by planetary observers that the best aperture for planetary work is about 15 inches. Equipment of this size is not vastly expensive.

A somewhat novel design of telescope is specially adapted to an equatorial site. The lens is placed in a fixed mount with its optical axis horizontal, and in the meridian—parallel to the earth's axis. Conveniently placed within each focus is a plane mirror. These mirrors are elliptical: minor axis, 1; major axis $\sqrt{2}$. The mirrors are pivoted about declination axes. The northern mirror surface when inclined to the optical axis from 90° to 45° sends a full beam of light through the object glass from all southern declinations. Similarly the southern mirror commands the northern hemisphere. The declination axes, with the mirrors, are mounted in ball bearings so that they can be bodily rotated about their horizontal—polar—axes. Each of the plane mirrors has a small circular hole in it, enabling the focused beam from the other mirror to pass through it. The northern mirror and the southern eyepiece are rigidly connected; similarly the southern mirror and northern eyepiece. Thus we have two independent "Polar Equatorials" using one lens. Such a construction has many advantages. Saving is effected; one lens doing double work; no dome needed; small driving clocks are adequate, since the work on them is uniform and well balanced. Also, the only moving parts are the eyepieces and the plane mirrors, which merely rotate about a fixed horizontal axis. The observers always work in comfort; eyepieces do not move bodily. All parts of sky are equally accessible.

The equator is the best location from which to investigate the following problem:

Meteoric Satellites of the earth. Analogies suggesting their pressence:

Jupiter's Fifth Satellite is distant	2.6	Radii from his Centre.
Mars' First (Phobos)	2.76	Radii.
Saturn's Ring—Inner Edge.	1.37	Radii.
Outer Edge.	2.49	Radii.

A satellite of the earth with period of 6 hours would be distant, 2.66 radii from centre. Such a satellite would transit the same meridian every 8 hours—(motion direct). It could never rise to observers in Lat. 69° N. or S. and would appear low in the sky, outside the zodiac, to most observatories now existing. If it were fainter than the fourth magnitude it would scarcely be detected by naked eye, and would only be caught occasionally in telescopes, when it would pass for a meteor, on photographs, if it appeared at all. Such bodies therefore may exist unknown. Such a satellite might occasionally be seen in transit upon the sun.

In an early edition of Webb's "Celestial Objects," the writer found a list, extending over a century, of anomalous black spots, seen by various observers, upon the sun. A plot of Solar eclipses for the same period served as a detective. Months were plotted horizontally; years vertically. Of course the eclipses all fell into a series of parallel lines slanting across the paper—18 years 10 days apart. It was also found that a similar series of slanting lines approximately represented the

majority of Webb's objects. This lends color to the supposition that these objects are satellites of the earth. The observations are various and discordant, but the hint remains, and may possibly lead to interesting discoveries. Meteoric satellites would sooner or later be compelled to move in the plane of the equator, and would transit the zenith of an equatorial site every revolution. Extremely small bodies could be detected with moderate means. A body one foot in diameter and distant 2.66 radii from earth's centre would appear as a stellar point of the fifteenth magnitude. It seems quite probable that the earth in the long process of time has captured at least a few bodies larger or nearer than this, which can be located easily.

In conclusion may I repeat that an astronomical observatory near Quito is an urgent need at the present moment. Its uses are manifold; its cost moderate. And, incidentally, observations of Mars in 1924, the most favorable opposition of the century, would be very acceptable first fruit of such a venture. I hope this paper will serve a useful purpose in drawing attention of all astronomical students to the unique opportunities offered by this site.

OCCULTATION OF ALDEBARAN, 1922, SEPTEMBER 13, AS VISIBLE IN THE UNITED STATES.

By WILLIAM F. RIGGE.

Occultations of bright stars or of planets have been so exceedingly rare of late in the United States, that amateurs have probably struck them off their lists entirely, and possibly may not even know the meaning of the word, that an occultation is an eclipse of a Star by the Moon. With a crescent moon in the early hours of the night and in a clear sky, an occultation of a bright star or a planet is a sight that will long be remembered. The instantaneous suddenness of the disappearance and reappearance of the star, especially at the moon's dark edge, will certainly startle an observer that sees it for the first time.

While the moon is our nearest celestial neighbor and is therefore always between us and the distant stars, it must be continually eclipsing or occulting those that lie in its apparent path. We might therefore expect to see such occultations happening by the score every time that we chose to look at the moon. While this is correct in principle it is sadly deficient in practice. From the large number of these possible occultations we must, first, strike out the half that take place when the moon is below our horizon. We must, next, cancel those that happen when the moon is new and near the sun, as well as when it is full or nearly so, and when it is above our horizon in the day time, and also when it is very low in the sky even at night. The shrunken number is still further reduced by the omission of all the stars that

are too faint to be seen near the bright moon even with a telescope. With but a hint at the caprices of the weather, we can now readily understand why observable occultations should be so very few.

The *American Ephemeris*, it is true, has one or more on its list for almost every day of the year except when the moon is too near the sun, and POPULAR ASTRONOMY has generally published those that were to happen until its next issue. But now another consideration comes to dispirit the interested amateur, the moon's nearness to the earth, which projects its apparent place upon the background of the stars in such a complicated way that it needs but a few trials to convince him that the given list is practically of no use whatever to him, because either the expected occultation does not happen at all, or it takes too long to wait for it to actually occur. Of late the *Ephemeris* has tried to obviate this great uncertainty by stating that the occultation will be visible either all over the United States or only in certain parts. But it is very doubtful whether this additional labor has met with any proportionate success in practice, mainly because the times and the regions can be given only very vaguely and the stars are too faint. What the amateur really wants is a map that gives him all the data he needs within a few minutes of time and a few degrees on the moon's limb. Such maps are, of course, too laborious to construct except for exceptionally fine occultations, such as the coming one of Aldebaran, a first magnitude star, on next September 13, and others to be mentioned later. Before we explain their use, however, let us briefly establish our thesis concerning the actual rarity of the occultations of bright objects, by recalling the most recent dates on which they were visible in the United States.

The last one on our list was β Capricorni, only of the 3.2 magnitude, in 1919 November 27, visible only over the southern and eastern states, with a crescent moon about five days old. This was preceded by π Sagittarii, of the 3.0 magnitude, in 1918 August 18-19, visible about midnight, with the moon only about two days from being full. Before that came Saturn between 2 and 3 A. M. in 1916 August 25, with a crescent moon, visible over the eastern half of the United States. The occultation of Venus in 1913, September 27, occurred in the day time, and even then was theoretically visible only to a few north-central states. The last occultation of a first-magnitude star that was at all visible under fairly passable conditions was that of Antares over ten years ago, in 1912 June 26, between 9 and 11:50 P. M., but the moon was nearly full. The maps of all these occultations were published in due time in POPULAR ASTRONOMY, except that of Saturn, which was in the *Scientific American*.

But now, fortunately, the tide is turning, and Cynthia promises to be more accommodating. She offers us the coming occultation of September 13 as a specimen of what she can do. It is not all that we would wish, since most of the southern states will not be favored at

all, and even the rest will have much or all of it ruined by the sun. Let us not be too fastidious after our long wait of so many years. Aldebaran will be occulted again under various conditions on December 4, and three times more next year 1923; on January 27, September 3, and November 24. In addition we have the promise, also for next year, of a superb occultation of Venus on January 13 and of Saturn on September 12. The maps of all these are ready and will be published in proper time.

Coming down, now, to the first occultation on our list, we see that

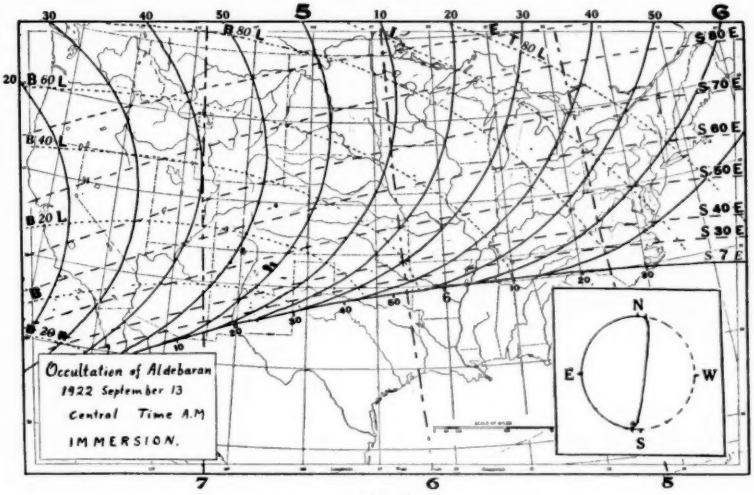


Fig. 1

Fig. 1 is drawn for the Immersion or disappearance of Aldebaran behind the moon on the morning of next September 13. The large 5 and 6 on the upper margin mean 5 and 6 A. M. central time, and the smaller numbers from 10 to 50 are the preceding and following ten minute intervals, from which by estimation we may get the nearest minute for our place. The dashed lines marked E, S 80 E..... S 7 E, indicate the position angles on the moon measured from its south point, at which the star will disappear, and the dotted lies B 20 R, B.....B 80 L, L, T 80 L, give this same point as measured from the bottom B or top T of the disk towards the left L or the right R. These position angles are really not necessary for the immersion, but they may guide us at the emersion. The moon's shape is shown in the insert. The phase is near that of last quarter, with the left or east half of the disk illuminated, and the north end of the terminator about 8° to the west of the north point N. The southern limit of the occultation is sufficiently intelligible without explanation. Places on this curve will see

a grazing contact at the central times indicated. The large numbers 7, 6, 5, on the lower margin show the central time of sunrise, from which we may gage the visibility of the occultation at any place.

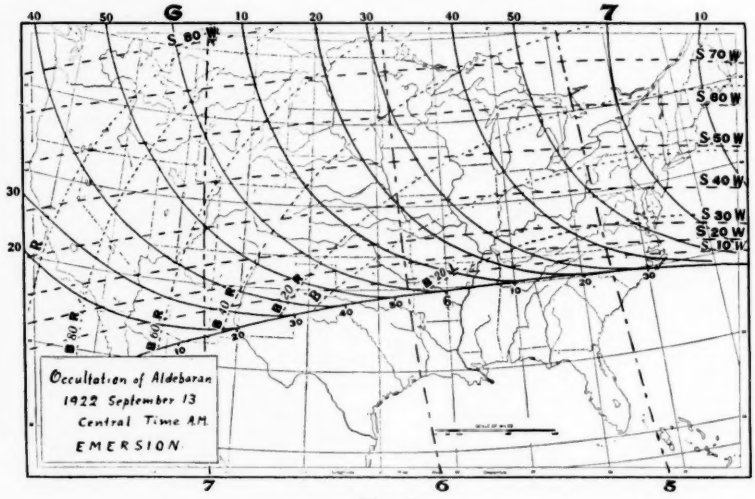


Fig. 2

Fig. 2 gives the same data for the Emersion or reappearance of the star, which will take place at the moon's dark limb. The times of sunrise and of the grazing contacts are repeated from Fig. 1.

WHAT ABOUT MARS?

By W. H. PICKERING.

While the writer has but little time for what may properly be called controversial articles, yet the recent paper by Professor Porter, under the above title, published in POPULAR ASTRONOMY, 1922, **30**, 268, would seem to demand some attention. Coming from so well known and able an astronomer, yet representing in some respects such archaic views, it is impossible to simply ignore it. It was evidently written with the best of motives, to silence the sensation mongers, yet in the interest of the public it appears desirable to at least point out what facts relating to Mars are at the present time debatable, and what are not.

To begin with, in the early portion of his article Professor Porter greatly understates his case. Thus he begins by assuming that a magnifying power of 1000 diameters can be employed on Mars. Now I do not know of any astronomer who uses such a power. The very

highest used by experts in studying the canals and finer detail is only 500. To use 1000 would be simply preposterous. In order to obtain the greatest accuracy in sketching the coarser detail, I myself often use a power of 660, but never to study the canals and finer markings. He next assumes that magnifying the planet 1000 times is equivalent to bringing it 1000 times nearer,—a quite erroneous supposition, and that we may possibly see the planet as well as we could with the naked eye at a distance of 25,000 miles. Had he ever seen the planet with a large telescope under even the most favorable conditions I think he would never have suggested such an idea. We see the moon at ten times this distance with the naked eye, and at practically four times this distance with an ordinary opera glass, but we never see Mars as well with the telescope as we do the moon with an opera glass, and generally see it but little better than we see the moon with the naked eye. Instead of our seeing Mars as at a distance of 25,000 miles, if he had said at a distance of 200,000 miles he would have been much nearer the truth.

Professor Porter next quotes the statement by Professor Campbell comparing my drawings of the canals with those of the late Dr. Lowell. That comparison was ingenious, and has always appealed to me. There is no question in my mind that either my style of representation of the planet is entirely wrong, and Dr. Lowell's correct, or *vice versa*. Dr. Lowell's style of representation is fully confirmed by his assistant, Mr. E. C. Slipher, and of late by Mr. Hamilton, also of the Lowell Observatory. The best English observers, such as Phillips, Thomson, and Steavenson, and Professor Douglass of Arizona see the planet as I do. The Lowellian photographs, which are of the very highest class, bear no resemblance in their style it may be remarked to the Lowellian drawings. They both show the same canals, that is all. Of them Mr. Thomson recently said "To my eye the [Lowell] photographs represent Mars just as we see it in this country, though of course, not quite as clearly or well defined" (*Journ. B. A. A.* 1922, **32**, 165.)

Personally I have always looked on the Lowell drawings as diagrams or possibly maps of the planet showing where they saw their canals, rather than as representations of its appearance. Some of the canals that I see appear to me quite as fine as those represented by the Lowell observers, but the majority of them are very much wider. In 1920 some canals appeared to me within Elysium, which Dr. Lowell had previously described as exceptionally fine. They were noted also by Mr. Phillips in England. When I erected the first telescope for Dr. Lowell in Arizona, one of 18 inches aperture by Brashear, I observed there for six months. Lowell and I often compared notes, and he tried unsuccessfully to make me see the duplication of the canal called Ganges, a double which he thought was particularly clear. My drawings of the canals always appeared to him too wide, and his drawings appeared to me too narrow, too nearly of the same width, and particu-

larly too straight. Neither could convince the other, and what was perhaps worse, Professor Douglass, who was also there, saw the canals even wider than I did!

Professor Porter next states that the mean annual temperature of Mars is probably lower than —39° F. This statement is based not on an observation of any sort, but on mere mathematical formulae. As we all know, when used in cases to which they are not applicable, there is nothing that will lie like figures,—not even photographs. The mean annual temperature of Mars cannot be determined as yet, but is certainly below +32° F. and may perhaps be reckoned at +20°, as compared with a mean annual temperature for the earth of +59°. The mean equatorial temperatures we know better, and are probably about +40° and +80° respectively. We estimate the temperature for Mars by the facts that snow is never seen on the equator at Martian noon, but when the planet is near aphelion is sometimes seen on the equatorial limb soon after sunrise, and that frost has even been seen to form in the torrid zone in the early afternoon. At night therefore the temperature must fall below 32°. At noon it may perhaps reach 60° to 70°.

What should surprise us, indeed, is not that the equatorial temperature of Mars is as high as it is, but rather that that of our earth is so low. This is doubtless chiefly due to our oceans. Enormous quantities of heat are absorbed in the evaporation of the water, and are radiated into space from our cloud surfaces. In our deserts much higher temperatures are reached. A temperature of 130° F. was recorded by the Weather Bureau in Death Valley, California, not may years ago. The oceans are also cooled by our extensive polar caps, while much heat is reflected away from our sunlit cloud surfaces as well as from the caps themselves. On Mars, excepting for a few weeks, the caps are insignificant, midday clouds are almost unknown, while the nights are undoubtedly extremely cloudy, as has been explained elsewhere, and as is indicated by the extensive clouds usually seen along the limb, and sometimes along the terminator of the planet. Freedom from cloud by day tends to heat the surface of a planet, while cloudy nights tend to keep it warm. On the earth, over a very large portion of the surface, the reverse conditions prevail, with cloudy days and clear nights. This is especially true in the tropical regions. This tends further to reduce the difference between Martian and terrestrial temperatures. None of these conditions are properly subject to computation.

I am afraid Professor Porter is a little weak in his meteorology when he says the sun does not melt the snow upon high mountain peaks. I have myself waded through melting snow up to my knees, with a hot sun overhead in the Andes, at an altitude of over 19,000 feet, and nearly half of the earth's atmosphere below me. Somewhat later in the season the whole of that particular mountain was clear of snow, some ten square miles or more of it having melted in the mean time. The atmospheric pressure on its summit is only about double that which we believe exists on Mars.

In order to explain the melting of the polar caps of Mars at the low temperature which he advocates, Professor Porter goes back to the ancient belief that they are composed of solidified carbon dioxide. We had supposed that that idea was buried in the remote recesses of a past antiquity, but like circle squaring and the flat earth you can never tell where it may crop up again. When the polar caps are forming they stand out contrasted directly with the ground on which they lie. When they begin to melt this is also true, but after a few weeks a dark line beginning near the noon meridian, and extending to the sunset limb or terminator becomes more and more marked. It was recorded here for the first time this year bounding the southern polar cap on May 9, corresponding to ⊙ 154°.1, or Martian Date August 46. In a few weeks it will have extended back to the sun-rise meridian, and will then clearly and completely divide the polar cap from the rest of the planet. It will then broaden to several hundred miles, retreating with the snow cap as the latter melts, and keeping in contact with it. During favorable years dark bays form in it from which yellowish white clouds may be seen to rise, and later when the cap grows smaller and thinner a black area sometimes appears within its borders.

As on our earth, we cannot doubt that this black material is the product of the melting of the cap, in other words water. At atmospheric pressure as we all know water boils at 212°. As the pressure diminishes the boiling point is lowered. When the pressure is reduced to a little over 4 millimeters the boiling point is reduced to the melting point, and below that pressure water cannot exist. That is to say snow when exposed to the sun disappears, not by melting, but by evaporating into steam.

Now let us go back to Professor Porter's theory of polar caps composed of solidified carbon dioxide. In the first place it is highly improbable that carbon dioxide should exist in such extraordinarily large quantities upon Mars. In the second place supposing that it did exist there, it is well known that just as water cannot occur at a pressure below 4 millimeters, so liquid carbon dioxide, no matter what the temperature may be, cannot exist at a pressure less than five terrestrial atmospheres. Does Professor Porter wish us to believe that the atmosphere of Mars is five times, or more, as dense as that of the earth, and therefore contains twelve times as much gaseous material over every square foot of its surface? The planet's disk certainly does not present that appearance, for in that case we could see no surface details at all.

As the Martian southern snow cap melts, with the coming of the autumnal equinox a few weeks hence, the southern maria will turn green, and remain so for about three terrestrial months. After this they will resume their usual gray tint. Green is not a color which we are in the habit of associating with a temperature of 39° below zero.

Professor Porter states that the Lick observations prove the absence

of water vapor in the atmosphere of Mars. In this he is mistaken. Professor Campbell concluded that in the atmosphere of Mars there was at the time that his observations were made less than one quarter as much moisture as there was in the atmosphere of the earth. Since the temperature of Mars is lower than that of the earth we should expect it would be less. The Lick observations were made many years ago, before we knew as much about the meteorology of Mars as we do at the present day. It so happened by an unfortunate coincidence that the observations were made at the time when the desert conditions on the planet were most pronounced. Had they been made during the few weeks when the melting of one of the polar caps is most marked, and the moisture was being conveyed across the equator to the other pole, to be deposited as snow, it is probable that a very different result would have been obtained.

Professor Porter closes by saying that whatever the streaks on the planet's surface may be, they certainly are not canals. Here at least we may agree with him, if he means water canals. But then that idea was punctured just thirty years ago, and the term "canal" in astronomy ever since that time has been used simply to mean a dark elongated narrow planetary marking, either straight or curved, but not crooked.

May 15, 1922.

Mandeville, Jamaica, B. W. I.

NORWICH MEETING OF THE A. A. V. S. O.

BY GEORGE C. WALDO, Jr.

With the dedication of "Starlight House," the fine new observatory of W. Tyler Olcott as an added attraction, the Spring session of the American Association of Variable Star Observers, held on June 3rd at Norwich, Conn., proved to be one of the most enjoyable astronomical "get togethers" in the history of the Association. About 27 members attended the semi-annual meeting which was held at the home of Mr. and Mrs. Olcott, 62 Church Street, and the banquet which followed at the Wauregan hotel, and letters were received from a number of the members in distant points who were unable to attend the gathering. One of these letters was from Miss Annie Cannon of the Harvard Observatory, now at Arequipa, Peru, who wrote most interestingly of the spectroscopic work now in progress at the Harvard station there.

Among the important business matters before the meeting was the report of the nominating committee, which offered the following slate for election at the November meeting of the association:

For president, Prof. Anne S. Young.
For vice president, J. Ernest G. Yalden.
For the Council, Leon Campbell and Arthur C. Perry.

It was also announced that the cash or pledges for the Edward C. Pickering Memorial fund were now in excess of $4,000 and the work of swelling this sum to an amount sufficient to carry out the purpose of the Fund will be actively pressed and every avenue of publicity will be utilized. One of the novel means to be employed to awaken public interest in astronomical matters will be an address by radio, to be given by David B. Pickering from Station W J Z of the Westinghouse company at Newark, N. J. This will reach an audience estimated at about 200,000 persons and it is hoped, will be the forerunner of many other astronomical talks to be broadcasted through this and other large wireless stations.

An instructive paper by Dr. P. W. Merrill on "The Spectroscopic Investigation of Long Period Variable Stars," was read at the meeting. Miss Harwood contributed a note on the variation in the light of the asteroid Iris, and Miss Woods, who appears to be the champion discoverer of novae, received another bar to her gold medal for the finding of a nova and in addition announced the discovery of a new Algol-type variable. The reading of papers concluded with a very interesting talk by President Leon Campbell accompanying the exhibition of a number of new lantern slides contributed from various sources to the Association's collection.

The meeting then adjourned to the upper floor of the Olcott home to assist in the formal dedication of "Starlight House," the observatory which now houses Mr. Olcott's five-inch refractor. Unique features of this observatory include a specially designed zenith shutter and slide, operated instantly by pulling a rope inside the observatory, and a rising and falling steel pillar, operated by a gear and crank. By means of this latter device the eye end of the equatorial may be raised or lowered to any desired point, so that the observer need not use either a ladder or a star diagonal; yet the steel pillar is milled with such accuracy that a setting obtained at any point will be retained through out its length. The octagonal dome of the observatory is supported upon ball-bearing roller skate wheels and moves with sufficient ease to be rotated with one hand. Because of the situation of the observatory on top of the Olcott house, which is at the summit of a high hill, the observer commands a splendid horizon. In fact the esthetic features of "Starlight House" are hardly secondary to its scientific and practical arrangements. From the windows one enjoys a vista of miles down the beautiful valley of the Thames and the place is one to attract pilgrims in the daytime as well as during the hours of observation.

The A. A. V. S. O. through its membership now commands a number of well designed, well equipped private observatories, with several

more planned or under construction. The publication of descriptive articles in POPULAR ASTRONOMY has greatly stimulated interest and has resulted in a steady stream of inquiries for plans and specifications, indicating a growing realization that in the matter of the amateur's equipment the observatory is hardly secondary to the instrument.

Following the dedication of the observatory, which was signalized with the breaking of an appropriate bottle on the pillar of the instrument, the members were entertained by Mrs. Olcott at tea, after which they adjourned for the evening's banquet at the Hotel Wauregan. Here they were welcomed to Norwich by the Rev. Dr. Selden, a local clergyman, and then followed an evening of delightful informality in which the witty grilling of the toastmaster, David B. Pickering, brought forth responses in kind. It was not until the lateness of the hour ordained a conclusion that the Spring meeting of the Association was finally adjourned by President Campbell, with many warm expressions of appreciation for the delightful hospitality of Mr. and Mrs. Olcott and the charms of Norwich as a meeting place.

VARIABLE STAR OBSERVING.

By D. F. BROCCHI.

The principal classification of variable stars into short period and long period variables is by no means artificial. It is not a matter of convenience, it is a matter of decided difference. Every short period variable is a system of two or more bodies revolving about their common center of gravity, and the variation of brightness is only apparent, being due to their change of position with reference to our line of sight. This at least seems to be the case with most of them, if not for all, but at any rate the cause of their variation is either fairly well known or well on the way of being explained. The variation being regular and the period averaging only a few days, it is possible to obtain the necessary data for their study with a comparatively short number of observations.

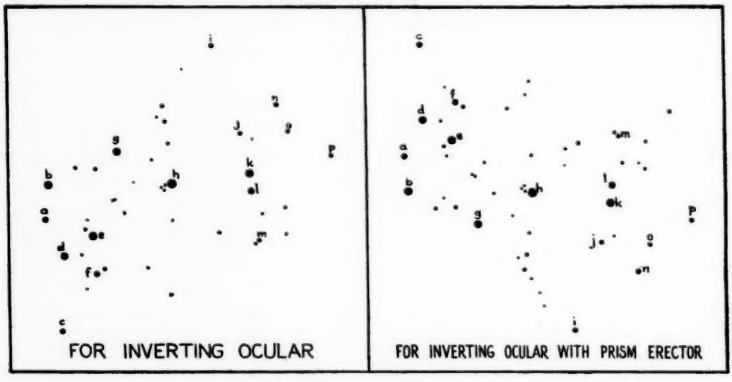
Every long period variable, on the contrary, is a single body, and the variation of its brightness is not only apparent, but actual and evidently due to physical and chemical changes taking place in its substance. The average length of period is about one year and the fluctuations of light are more or less irregular and in some cases so erratic that it is impossible to determine even an approximate period. Adding to these the fact that the number of these stars known at present is more than one thousand and is continually increasing, it is not surprising that comparatively little is known about them, the number of observations required to obtain the necessary data for their study being far in excess of what can be attended to by the professional astronomer. It is to

supply this deficiency that appeal is being made to amateurs for assistance. Very fortunately the range of variation of these stars is very pronounced, the brightness at maximum being in some cases more than 5000 times greater than at minimum. Consequently slight errors in the estimates even as large as one-half of a magnitude do not affect the value of the observation to a very great extent, although as a matter of fact, after the amateur has gained familiarity with the work, errors of two or three tenths of a magnitude are seldom exceeded.

The observation of variable stars is by far the most valuable and pleasurable use that can be made of a telescope of moderate size. No technical knowledge is required and no exacting routine is imposed. While stating, however, that no technical knowledge is required, it must be added that by such knowledge the work of the observer is made more valuable. Aside from the tendency that the possession of a technical education has to improve the accuracy of scientific work, the subject of variable stars is so comprehensive, that few indeed are the branches of technical knowledge that cannot help to make the work of the observer more efficient. It must also be stated that if much valuable work can be done even with a three-inch telescope, yet the larger the instrument the more valuable the work will be.

The American Association of Variable Star Observers furnishes to its members detailed instructions and a special chart for each variable, on which all the needed information is clearly shown. Mr. William Tyler Olcott, secretary, 62 Church St., Norwich, Conn., is never more pleased than when he has the opportunity to answer a letter of inquiry concerning the Association. The observer works entirely at his own convenience and is under no financial obligation with the exception of the membership fee, which is almost negligible. He feels that he is furnishing information of great value to solve the problems of cosmic evolution, while the never waning fascination connected with the work is a continuous source of pleasure. Looking at the moon, planets, double stars and other wonderful things in the heavens is indeed very pleasing and edifying, but in time they also lose their charm, become commonplace, and finally are entirely neglected. It is not to be wondered at, since this sort of occupation is all one sided, the sky doing all the work and our faculties not being called upon to co-operate. But to the variable star observer the active element is never lacking. He is like the hunter who matches his wits with the game, like the mountain climber who must reach the top at any cost, like the engineer who plans and directs the construction of a great bridge. Even the possibility of discovery is open to him, not all of the variables having been found by professionals in well equipped observatories. The star Z Puppis, a difficult variable to detect on account of its exceedingly long period, was discovered by Arthur C. Perry after three years' experience with a four-inch telescope, long before the Association came into existence, when the observer had to make his own charts, when

much of the necessary information, now furnished without asking, was very difficult to obtain or entirely unavailable. But the greatest of all the pleasures that reward the efforts of the diligent and conscientious observer is the satisfaction that no money can buy and that makes life really worth living, of having done good work for a good purpose.



Diagrams of the Pleiades.

The chart of the Pleiades which accompanies this article is intended especially for use by variable star observers, when the field of the variable is difficult to identify even with instruments provided with graduated circles. It is very helpful in this case to know beforehand how much of the telescope field will be occupied by a star configuration represented in the chart of the variable. Knowing the angular diameter of the field and the scale to which the chart is drawn, patterns of the field can be cut out of cardboard or other material, corresponding in size to the scales of the charts. In my case, for example, using the lowest power available on a six-inch telescope, I found the diameter of the field to be from *c* to *h*, that is 54′.4 or simply 54′. I have then cut my patterns as follows: 54^{mm} in diameter for a scale of $1' = 1^{mm}$; $(54 \times 60)/45 = 72^{mm}$ for $45'' = 1^{mm}$; $(54 \times 60)/30 = 108^{mm}$ for $30'' = 1^{mm}$; $(54 \times 60)/22.5 = 144^{mm}$ for $22''.5 = 1^{mm}$ and $(54 \times 60)/20 = 162^{mm}$ for $20'' = 1^{mm}$. It is to be understood, of course, that instead of 54, the actual diameter of the field is to be used in each case. The scale of the charts is found by measuring one degree of declination, as indicated on the edge, with a metric rule. Then

Length of 1°	Scale of Chart
60^{mm}	$3600/60 = 60'' = 1' = 1^{mm}$
80^{mm}	$3600/80 = 45'' = 1^{mm}$
120^{mm}	$3600/120 = 30'' = 1^{mm}$
160^{mm}	$3600/160 = 22.5'' = 1^{mm}$
180^{mm}	$3600/180 = 20'' = 1^{mm}$

Old style charts traced from H. C. O. photographs and showing no declination on the edge, are drawn to a scale of $20'' = 1^{mm}$. It will

be found that the charts do not measure quite as indicated, on account of shrinkage in the process of making blue prints. Allowance can be made for this, if desired, by cutting the patterns slightly smaller than calculated, although the shrinkage is not the same in all charts. This, however, is not very important, as the nature of the requirements does not necessitate a high degree of accuracy.

Seattle, Wash., Jan. 31, 1922.

AN ASTRONOMICAL CAMERA FOR AMATEUR WORK.

By R. C. LOWE.

Professor Todd in his most excellent work, "New Astronomy," says that "any good telescope or camera may be satisfactorily used in taking photographs of celestial objects. Remove the eye-piece and substitute in its place a small, light-tight plate holder. . . . . Insert a plate in this position and make an exposure of about half a second on the moon, if within two or three days of the 'quarter'."

On the strength of this information, the writer began to devise such a "plate holder," since Professor Todd does not give directions for doing so. The primary object in the constructing of this camera is efficiency coupled with simplicity of detail and a minimum pecuniary output. The directions for procedure are as follows:

Round up three pieces of wood in a lathe to the required diameter, which should be one and one-third times the length of the required film pack. The first piece must be about an inch in thickness in order to form a solid base for the other parts. Cut the second to the thickness of the film pack and remove a rectangular portion of it of the same size as the film pack.

Cut the third piece to a thickness of about three-eighths of an inch and in the center of it cut a hole equal to the eye end of the telescope tube. Then cut out another portion with a diameter equal to the projecting brass ring that terminates the eye end of the tube. This must be cut only to such a depth that the ring will lie flush with the inside surface of the third piece.

Cut two pieces of heavy flannel of the same diameter as the wooden pieces. Fit these between the three wooden parts to make a more light-tight joint. It will be found that the raised ring on the end of the tube near the eye can be removed. Then slip this piece through the front round piece of wood and replace in the telescope.

Next take the base and second pieces with the film pack in place, taking care to see that the end with the tabs protrudes, and screw the whole together with wood screws. The finished article as mounted on

a telescope is shown in the figure. Loosen the wood screws slightly when the pack is to be removed and simply pull it out.

No shutter is necessary with this camera because it is to be used only at night and there is little chance of the film being light-struck. A piece of cardboard, held over the lens until the tube is steady, is all that is required. After each exposure, while still holding the cardboard between the object and objective, replace the cap.

With this sort of camera, especially with an objective of over three inches, a finder should be used. Any small telescope will do for this.

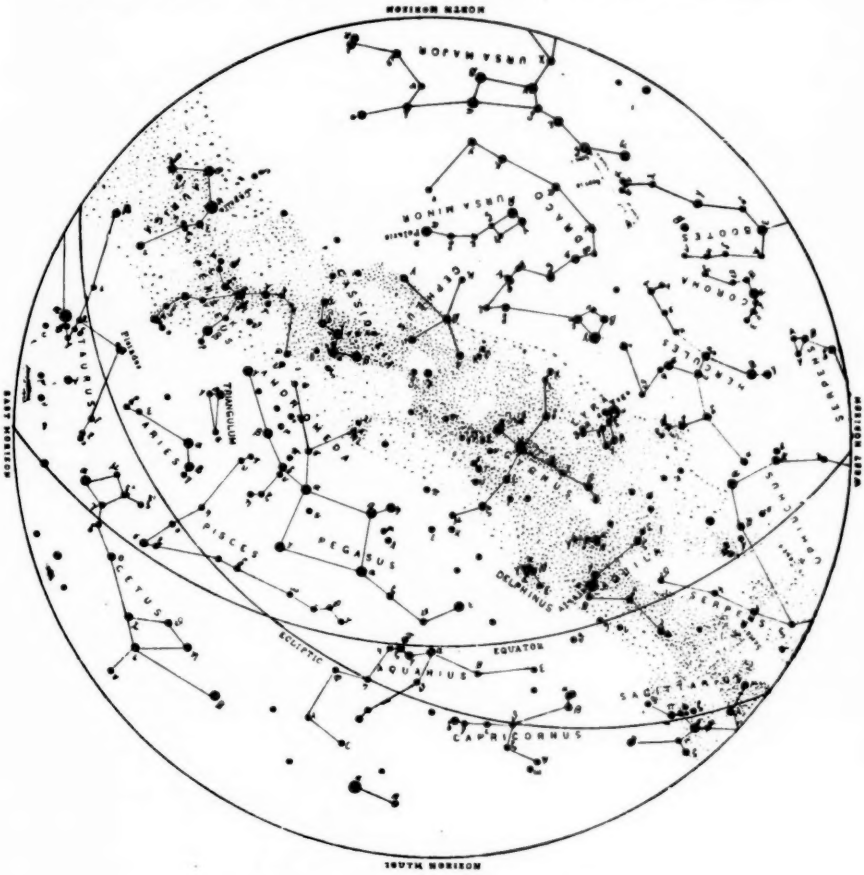
A method of supporting the finder to the telescope is as follows: Cut out two rings of wood, one having an inside diameter equal to the diameter of the large telescope tube and the other with the diameter of the finder. Cut these in half and glue the halves of one to the halves of the other as if placing two U's with their bases together. Then place these on the large tube at the proper distance apart and set the finder in the upper U's. Secure the whole by a strap passed around both tubes. It may require a little adjustment to make them center properly.

The fact that no eye-piece is used for magnification makes the image small in a small telescope, but with any glass of more than three or four inches aperture good results should be obtained, especially if one be fortunate enough to possess an equatorial, clock-driven, mounting.

The writer hopes that some traveler on the sea of Amateur Astronomy may find this article acceptable, and may derive as much pleasure and satisfaction from celestial photography as the writer has with apparatus made by his own hand.

PLANET NOTES FOR SEPTEMBER AND OCTOBER.

There will be a total eclipse of the *sun* on September 20. The line of totality begins in eastern Africa, crosses the Indian Ocean and Australia and ends in



THE CONSTELLATIONS AT 9:00 P. M. OCTOBER 1.

the western Pacific at about 173° E. Long. and in Latitude 30° south. A number of American and European parties are on the way to observe the eclipse and other parties will be sent out by the Australians. One of the principal objects sought for will be the gravitational effect on the path of light from the stars when passing near the sun as predicted by Einstein.

The *sun* enters Libra and autumn begins on September 23 at $2^h\ 10^m$ P. M.

The phases of the moon will occur as follows:

		d	h	m		d	h	m	
Full moon	Sept.	6	1	47.2	A. M.	Oct. 5	6	58.3	P. M.
Last quarter		14	4	20.0	A. M.	13	3	55.4	P. M.
New moon		20	10	38.3	P. M.	20	7	40.2	A. M.
First quarter		27	4	40.4	P. M.	27	7	26.4	A. M.

Mercury will make a reversed S curve in Virgo in these two months. The planet will be at greatest eastern elongation September 20 at 5 A. M. At this time it should be seen easily after sunset. It passes inferior conjunction October 15 at 5 A. M. and reaches greatest western elongation at 8 P. M. on October 30. As its distance from the sun at this second elongation will be only 18° 38′ it will not be seen except under very favorable conditions.

Venus will be a conspicuous object in the western sky after sunset during this period. It will reach greatest eastern elongation at 4 P. M. on September 15 and will have its greatest brilliancy at midnight of October 20. At this time its stellar magnitude will be —4.3.

Mars will be in the eastern part of Sagittarius on September 1 and will move eastward to the eastern part of Capricornus by October 31. The planet will be in fair position for observation during the early evening, as it will cross the meridian at $6^h\ 52^m$ P. M. on September 1 and at $5^h\ 36^m$ P. M. on October 31. During this time its distance from the earth will increase from 67,700,000 to 101,500,000 miles. On the average its distance from the earth will be increasing over half a million miles daily.

Jupiter and *Saturn* will be too close to the sun for satisfactory observation.

Uranus will be at opposition on September 4 at 5 P. M. On September 1 and October 1 its positions will be R. A. = $22^h\ 53^m\ 56^s$, Dec. = —7° 54′ 29″ and R. A. = $22^h\ 49^m\ 38^s$, Dec. = —8° 20′ 27″ respectively.

Neptune will not reach quadrature until November and therefore can be seen only in the morning sky before sunrise. The planet's position on October 1 will be R. A. = $9^h\ 19^m\ 55^s$, Dec. = +15° 44′ 46″.

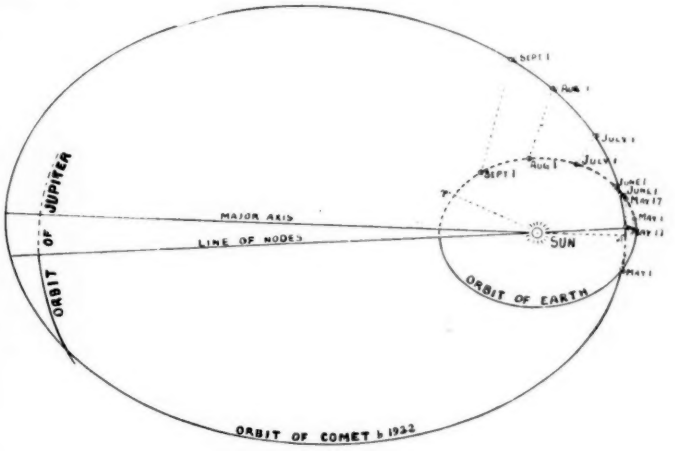
Occultations Visible at Washington.

[*From the American Ephemeris.*]

Date 1922	Star's Name	Magnitude	IMMERSION. Washington M.T.	IMMERSION. Angle from N	EMERSION. Washington M.T.	EMERSION. Angle from N	Duration
			h m	°	h m	°	h m
Sept. 2	27 G. Capricorni	6.2	12 3	60	13 19	261	1 16
12	70 Tauri	6.4	12 16	149	12 36	182	0 19
12	75 Tauri	5.2	13 34	78	14 52	252	1 18
12	Aldebaran	1.1	18 53	133	19 49	217	0 56
13	111 Tauri	5.1	15 14	125	16 13	217	0 59
14	292 B. Orionis	6.5	16 3	74	17 22	280	1 19
15	λ Gem.	3.6	16 8	149	16 47	214	0 39
16	30 B. Cancri	6.1	14 3	169	14 18	200	0 15
27	Y Sagittar.	5.4	4 35	88	6 4	271	1 29
27	95 B. Sagittar.	5.7	10 12	109	11 9	233	0 57
27	100 B. Sagittar.	5.0	10 58	45	11 47	297	0 49
28	ρ Sagittar.	4.0	8 59	105	10 07	227	1 8
Oct. 1	96 B. Aquar.	6.5	10 55	85	12 11	226	1 16
3	316 B. Aquar.	6.5	6 21	66	7 38	251	1 17
4	80 B. Piscium	6.3	6 11	128	6 47	190	0 36
5	155 B. Piscium	6.5	6 37	91	7 40	226	1 2
5	77 Piscium	6.4	17 15	108	18 6	219	0 51
10	318 B. Tauri	5.7	9 2	14	9 24	325	0 23
13	1 Cancri	6.0	16 43	58	17 45	323	1 2

COMET AND ASTEROID NOTES.

Elements of Comet *b* 1922 (Skjellerup).—The following elements of this comet were computed by Profs. Crawford and Meyer of the University of California and published in *Lick Observatory Bulletin* No. 341.



ELEMENTS.

T = 1922 May 15.5129 G. M. T.
ω = 355° 27′ 48″
Ω = 215 01 20 } 1922.0
i = 17 44 22
Log e = 9.948541
Log a = 9.854796
Log q = 0.494922
P = 5.52565 years

CONSTANTS FOR THE EQUATOR 1922.0.

$x = r\,[9.993257]\ \sin\ (299°\ 11'\ 06'' + v)$
$y = r\,[9.995051]\ \sin\ (207°\ 38'\ 24'' + v)$
$z = r\,[9.362580]\ \sin\ (257°\ 46'\ 00'' + v)$

They call attention to the fact that this orbit is very similar to that of Comet *c* 1902 which was discovered by Grigg in New Zealand.

The accompanying diagram was made using the elements given above. It shows the relation of the comet's orbit to the orbits of the earth and Jupiter.

Elements of the Asteroid HZ 1920.—The enclosed elements that I have computed and am sending to you are based upon three normals from about a dozen positions sent to me from Lick Observatory. If this is an asteroid it is a most remarkable one. If my elements are right (and they were computed *with great care*) at perihelion it is only about 4/10 of a unit beyond the mean distance of Mars from the sun, but at aphelion it goes out nearly as far as Saturn.

ELEMENTS OF THE ASTEROID HZ 1920.

Epoch = 1921, Jan. 12.3498 G. M. T.
M = 355° 59′ 48″.97
ω = 56 29 17.79
π = 77 48 18.56
Ω = 21 19 0.77
i = 43 5 15.28
Log e = 9.814601
Log a = 0.756535
Log q = 0.297445
Log Aphelion = 0.974686
μ = 260″.138
P = 4981.963

CONSTANTS FOR THE EQUATOR.

$x = r\,[9.986178]\,\sin\,(105°\ 54'\ 24''.14 + u)$
$y = r\,[9.685885]\,\sin\,(\ 43°\ 25'\ 34''.27 + u)$
$z = r\,[9.958566]\,\sin\,(\ 9°\ 9'\ 22''.79 + u)$

FRANK E. SEAGRAVE.

VARIABLE STARS.

Changing Period of S Orionis, *052404.* —This variable star of long period, discovered by Webb in 1869 and situated in the region of the Great Orion Nebula, appears to have undergone a marked change in period, especially during the years 1895 to 1914. A discussion by Mr. Campbell of a very complete series of visual and photographic observations extending over an interval of fifty-two years indicates that a mean period of 413 days represents the observations very satisfactorily until 1895. From 1895 until 1914, a value of 425 days satisfies the results decidedly better, and from 1914 until the present time, the period has held very closely to 416 days. The above values have been deduced from an inspection of the O-C curve computed on the basis of a period of 413.2 days.

The change in period is also well shown by reference to the following table, which gives the Julian dates of maxima and minima for the epochs there indicated, with the mean periods, as derived from the maxima, the minima, and from both. A plot of the values in the fourth and seventh columns indicates more probably a small progressive change in period. The mean light curve of the star presents a well marked stand-still about 80 days before maximum.

Epoch	Jul. Day Max.	Jul. Day Min.	Mean Epoch	Mean Period Max.	Mean Period Min.	Mean Period Both
0	2404100	2404324				
6	06607	06808	3.0	418	414	416.0
10	08212	08428	8.0	401	405	403.0
15	10301	10520	12.5	418	418	418.0
20	12348	12558	17.5	409	408	408.5
24	14013	14232	22.0	416	418	417.0
30	16587	16808	27.0	429	429	429.0
35	18712	18902	32.5	425	419	422.0
39	20392	20614	37.0	420	428	424.0
45	22890	23116	42.0	416	417	416.5

Harvard College Observatory Bulletin 769.

Minima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard time 6^h, etc.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1922 Sept.				Oct.			
	h m	° ′		d h	d	h	d	h	d	h	d	h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8			14	0			18	21
RT Sculptor.	31.5	—26 13	9.6—10.5	0 12.3	7	9	22	17	8	1	23	10
UU Androm	38.5	+30 24	10.7—11.9	1 11.7	7	15	22	12	7	8	22	5
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	3	7	25	18	3	5	18	4
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	4	10	22	18	4	23	23	8
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	6	9	20	15	4	22	26	8
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	4	15	25	6	8	23	22	17
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	5	0	19	8	3	16	25	5
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	3	21	21	10	9	0	26	13
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	4	8	20	6	6	3	22	0
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6			29	21				
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	7	2	24	7	11	11	28	16
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	7	15	21	6	4	20	25	5
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	3	11	19	6	5	2	20	21
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	8	14	25	5	3	13	20	3
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	4	20	20	14	6	9	22	4
RW Persei	13.3	+42 04	8.8—11.0	13 04.8	6	15	19	20	3	1	29	10
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	10	5	19	15	8	13	27	10
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1	2	19	27	15	10	1	22	12
TT Aurigæ	5 02.8	+39 27	7.8— 8.7	0 16.0	6	0	19	7	2	15	22	15
RY Aurigæ	11.5	+38 13	10.7—11.7	2 17.5	4	8	20	17	7	1	23	10
RZ Aurigæ	42.9	+31 40	10.6—13.3	3 00.3	4	23	17	0	5	1	23	3
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	5	4	22	12	9	20	27	4
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	4	1	24	20	5	6	26	2
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	4	14	20	14	6	15	22	16
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	4	23	22	4	3	15	20	19
U Columbæ	6 11.2	—33 03	9.2—10.0	2 19.2	2	15	19	10	6	5	23	0
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	3	13	19	22	6	8	22	18
RW Monoc	29.3	+ 8 54	9.0—10.8	1 21.7	9	9	24	15	9	21	25	3
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	7	1	19	6	1	11	25	21
RU Monoc.	6 49.4	— 7 28	9.8—10.5	0 21.5	2	15	16	23	1	7	22	20
R Can. Maj.	7 14.9	—16 12	5.8— 6.4	1 03.3	4	22	18	13	2	4	22	15
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	9	7	27	22	7	5	25	19
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	2	22	22	17	5	23	25	19
TX Gemin.	30.3	+17 08	10.0—11.9	2 19.2	2	20	19	15	6	10	23	5
RR Puppis	43.5	—41 08	9.4—10.7	6 10.3	5	21	18	18	8	1	27	8
V Puppis	7 55.4	—48 58	4.1— 4.8	1 10.9	6	11	21	0	5	13	20	2
X Carinae	8 29.1	—58 53	7.9— 8.7	0 13.0	5	7	21	12	7	18	24	0
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	10	9	19	20	8	20	27	19
RX Hydræ	9 00.8	— 7 52	9.1—10.5	2 06.8	5	16	26	4	9	21	23	14
S Velorum	29.4	—44 46	7.8— 9.3	5 22.4	6	10	24	5	6	2	23	22
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	3	13	23	19	7	7	20	18
RR Velorum	10 17.8	—41 36	10.0—10.9	1 20.5	4	23	19	19	4	15	19	11
SS Carinæ	10 54.2	—61 23	12.2—12.8	3 07.2	5	15	18	20	2	1	21	20
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	8	14	26	5	5	0	22	14
RW Urs. Maj.	35.4	+52 34	10.3—11.4	7 07.9	5	17	20	9	5	1	19	17
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	3	12	18	1	1	15	22	0
RZ Centauri	12 55.6	—64 05	8.5— 8.9	1 21.0	2	10	17	10	2	10	17	11
RS Can. Ven.	13 06.3	+36 28	7.5—12.5	4 19.1	2	11	21	16	10	20	30	1
SS Centauri	07.2	—63 37	8.8—10.4	2 11.5	3	3	17	19	10	7	25	4
133926 Hydræ	13 39.0	—26 23	8.6—12.7	2 21.5	6	2	23	11	5	1	22	10

Minima of Variable Stars of Short Period—Continued.

Star	R.A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of minima in 1922							
								Sept.				Oct.			
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
δ Libræ	14	55.6	—	8 07	4.8— 6.2	2	07.9	4	21	18	15	2	9	23	1
U Coronæ	15	14.1	+32	01	7.6— 8.7	3	10.9	2	7	23	0	6	19	20	15
TW Draconis		32.4	+64	14	7.3— 8.9	2	19.3	3	12	20	8	7	4	24	1
SS Librae	15	43.4	—15	14	9.3—11.5	0	18.4	8	9	23	16	9	0	24	7
SW Ophiuchi	16	11.1	—	6 44	9.2—10.0	2	10.7	2	1	24	1	8	17	23	9
SX Ophiuchi		12.6	—	6 25	10.5—11.2	2	01.5	7	21	24	9	2	15	19	3
R Aræ		31.1	—56	48	6.8— 7.9	4	10.2	2	5	19	22	7	15	25	8
TT Herculis	16	49.9	+17	00	8.9— 9.3	20	18.1	2	9	23	3	13	21		
TU Herculis	17	09.8	+30	50	9.5—12	2	06.4	6	11	20	2	3	17	24	3
U Ophiuchi		11.5	+	1 19	6.0— 6.7	0	20.1	5	1	22	10	9	4	25	23
u Herculis		13.6	+33	12	4.6— 5.4	2	01.2	4	18	23	5	6	12	23	23
TX Herculis		15.4	+42	00	8.3— 9.0	1	00.7	5	6	17	15	6	4	24	16
RV Ophiuchi		29.8	+	7 19	9. —12	3	16.5	6	5	20	23	5	17	20	11
SZ Herculis		36.0	+33	01	9.5—10.3	0	19.6	7	14	23	23	10	8	26	16
TX Scorpii		48.6	—34	13	7.5— 8.2	0	22.6	6	14	21	16	6	18	21	19
UX Herculis		49.7	+16	57	8.8—10.5	1	13.2	2	22	18	10	3	21	19	9
Z Herculis		53.6	+15	09	7.1— 7.9	3	23.8	5	20	21	20	7	19	23	18
WX Sagittarii		53.6	—17	24	9.2—10.8	2	03.1	5	19	20	20	9	20	26	21
WY Sagittarii	17	54.9	—23	01	9.5—10.6	4	16.0	2	4	20	20	9	12	28	5
SX Draconis	18	03.0	+58	23	9.3—10.5	5	04.1	6	15	27	7	7	15	28	7
RS Sagittarii		11.0	—34	08	5.9— 6.3	2	10.0	6	3	20	15	5	2	19	14
V Serpentis		11.1	—15	34	9.5—11.1	3	10.9	7	12	21	7	5	3	18	22
RZ Scuti		21.1	—	9 15	7.4— 8.3	15	03.2	3	8	18	11	3	15	18	18
RZ Draconis		21.8	+58	50	9.5—10.2	0	13.2	7	11	21	18	6	2	20	10
RX Herculis		26.0	+12	32	7.0— 7.6	0	21.3	4	22	19	3	3	9	24	17
SX Sagittarii		39.7	—30	36	8.7— 9.8	2	01.8	8	21	25	11	3	19	20	10
RR Draconis		40.8	+62	34	9.3—13	2	19.9	5	4	22	4	9	3	26	3
RS Scuti		43.7	—10	21	9.3—10.3	0	15.9	5	15	18	22	2	5	22	3
β Lyræ		46.4	+33	15	3.4— 4.1	12	21.8	11	11	24	8	7	6	20	4
U Scuti	18	48.9	—12	44	9.1— 9.6	0	22.9	10	15	25	22	3	13	18	20
RX Draconis	19	01.1	+58	35	9.3—10.2	1	21.4	8	21	24	1	9	4	24	8
RV Lyræ		12.5	+32	15	11. —12.8	3	14.4	4	12	18	21	3	7	24	21
RS Vulpec.		13.4	+22	16	6.9— 8.0	4	11.4	3	13	21	11	9	8	27	6
U Sagittæ		14.4	+19	26	6.5— 9.0	3	09.1	5	9	18	22	2	10	22	17
Z Vulpec.		17.5	+25	23	7.3— 8.5	2	10.9	5	9	20	3	4	20	19	14
TT Lyræ		24.3	+41	30	9.4—11.6	5	05.8	6	1	21	18	7	12	23	6
UZ Draconis		26.1	+68	44	9.0— 9.8	1	15.1	5	14	25	4	8	5	21	6
SY Cygni	19	42.7	+32	28	10 —12	6	00.2	8	0	20	0	8	1	20	1
WW Cygni	20	00.6	+41	18	9.3—13.4	3	07.6	3	13	16	20	6	17	20	0
SW Cygni		03.8	+46	01	9. —11.7	4	13.8	9	10	27	17	6	20	25	3
VW Cygni		11.4	+34	12	9.8—11.8	8	10.3	5	15	22	12	9	9	26	5
RW Capric.		12.2	—17	59	8.8—10.6	3	09.4	2	7	22	15	6	5	19	18
UW Cygni		19.6	+42	55	10.5—13	3	10.8	8	15	22	10	6	5	20	1
V Vulpec.		32.3	+26	15	8.2— 9.8	37	19.0			28	23				
W Delphini		33.1	+17	56	9.4—12.1	4	19.4	4	8	23	13	3	4	22	9
RR Delphini		38.9	+13	35	10.5—11.8	4	14.4	4	10	22	20	2	1	20	10
Y Cygni		48.1	+34	17	7.1— 7.9	1	12.0	8	2	23	2	8	1	23	1
WZ Cygni		49.3	+38	27	9.9—10.8	0	14.0	7	12	22	17	7	21	23	2
RR Vulpec.	20	50.5	+27	32	9.6—11.0	5	01.2	9	11	19	14	9	19	30	0
VVCygni	21	02.3	+45	23	12.1—13.8	1	11.4	6	8	21	2	5	21	20	15
AE Cygni		09.0	+30	20	10.8—11.4	0	23.3	4	21	24	6	3	23	23	8
RY Aquarii		14.8	—11	14	8.8—10.4	1	23.2	6	19	22	13	8	6	24	0
RT Lacertæ	21	57.4	+43	24	9.1—10.5	5	01.7	1	23	22	5	2	9	22	16
UZ Cygni		55.2	+43	52	8.9—11.6	31	07.3			21	7			22	15
RW Lacertæ	22	40.6	+49	08	10.2—11.2	5	04.4	5	1	20	14	6	4	21	17
VW Pegasi		51.7	+32	41	10.0—10.6	5	06.4	6	18	22	13	8	8	24	3
TT Androm.	23	08.7	+45	36	11.3—12.6	2	18.4	6	6	22	20	9	10	28	1
Y Piscium		29.3	+	7 22	9.0—12.0	3	18.3	9	12	24	13	9	15	24	16
TW Androm.	23	58.2	+32	17	8.6—11.5	4	02.9	2	8	18	20	5	8	21	20

Maxima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard time 6^h, etc.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1922							
					Sept.				Oct.			
	h m	° ′		d h	d	h	d	h	d	h	d	h
SX Cassiop.	0 05.5	+54 20	8.6— 9.2	36 13.7			26	7				
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 01.7	10	5	26	12	4	15	20	22
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	9	2	24	14	2	7	25	13
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2	10	3	24	22	9	17	24	12
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	8	22	24	20	10	17	26	14
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	3	22	19	12	5	2	20	17
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	8	8	22	22	7	12	22	1
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0			15		1		17	
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	4	11	21	14	8	18	25	22
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	8	8	19	11	11	18	22	14
RX Aurigæ	4 54.5	+39 49	7.2— 8.1	11 15.0	5	5	16	20	10	2	21	17
SX Aurigæ	5 04.6	+42 02	8.0— 8.7	1 12.8	8	0	23	8	8	16	23	23
SY Aurigæ	05.5	+42 41	8.4— 9.5	10 03.3	9	9	19	12	9	19	19	22
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.5	3	13	19	0	4	10	19	21
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	2	20	19	11	6	1	22	15
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	8	8	23	12	8	15	23	18
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3	3	19	30	19			27	20
RT Aurigæ	23.0	+30 33	5.1— 6.0	3 17.5	4	9	19	7	4	5	19	3
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	3	4	17	14	9	5	23	14
W Gemin.	29.2	+15 24	6.7— 7.5	7 22.0	5	19	21	16	7	12	23	8
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	4	10	24	17	4	21	25	4
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5			23	3	15	9		
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	9	0	24	22	2	21	18	18
V Carinæ	8 26.7	—59 47	7.4— 8.1	6 16.7	3	22	24	0	7	10	20	19
T Velorum	8 34.4	—47 01	7.6— 8.5	4 15.3	10	9	28	23	8	5	26	19
V Velorum	9 19.2	—55 32	7.5— 8.2	4 08.9	2	3	19	15	7	2	24	14
Z Leonis	9 46.4	+27 22	7.9— 9.6	59 00.0	14							
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	8	18	22	8	5	22	26	6
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	5	0	18	5	8	1	21	6
S Muscæ	12 07.4	—69 36	6.4— 7.3	9 15.8	7	5	26	13	6	5	25	12
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	4	9	20	8	6	7	22	6
T Crucis	15.9	—61 44	6.8— 7.6	6 17.6	4	5	17	16	7	21	21	8
R Crucis	18.1	—61 04	6.8— 7.9	5 19.8	6	12	18	4	5	15	23	2
S Crucis	12 48.4	—57 53	6.5— 7.6	4 16.6	6	14	20	15	4	17	18	19
W Virginis	13 20.9	— 2 52	8.7—10.4	17 06.5	14	17			1	23	19	6
SS Hydræ	25.0	—23 08	7.4— 8.1	8 04.8	9	10	25	19	12	5	28	14
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	4	15	18	16	2	17	23	18
ST Virginis	14 22.5	— 0 27	10.3—11.4	0 09.9	2	0	18	0	4	20	21	6
V Centauri	25.4	—56 27	6.4— 7.8	5 11.9	6	21	23	9	4	9	20	20
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	8	4	23	6	8	8	23	10
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	1	17	16	13	1	9	23	15
R Triang. Austr.	15 10.8	—66 08	6.7— 7.4	3 09.3	7	2	20	16	4	5	24	13
S Triang. Austr.	15 52.2	—63 29	6.4— 7.4	6 07.8	2	8	21	8	3	23	22	22
S Normæ	16 10.6	—57 39	6.6— 7.6	9 18.1	11	8	30	20	10	14	20	8
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	9	5	26	22	5	19	23	12
RV Scorpii	16 51.8	—33 27	6.7— 7.4	6 01.5	2	23	21	3	3	6	21	11
X Sagittarii	17 41.3	—27 48	4.4— 5.0	7 00.3	2	22	23	23	7	23	22	0
Y Ophiuchi	47.3	— 6 07	6.1— 6.5	17 02.9	14	2	30	5			17	8
W Sagittarii	17 58.6	—29 35	4.3— 5.1	7 14.3	3	17	18	22	4	2	19	7
Y Sagittarii	18 15.5	—18 54	5.4— 6.2	5 18.6	5	19	23	3	4	16	22	0
U Sagittarii	26.0	—19 12	6.5— 7.3	6 17.9	7	6	20	17	4	5	24	11
Y Scuti	32.6	— 8 27	8.7— 9.2	10 08.3	3	12	24	4	4	13	25	5
Y Lyræ	34.2	+43 52	11.3—12.3	0 12.1	2	15	20	18	2	19	20	22
RZ Lyræ	18 39.9	+32 42	9.9—11.2	0 12.3	5	6	23	16	5	22	24	8

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1922					
					Sept.				Oct.	
	h m	° ′		d h	d h		d h		d h	d h
RT Scuti	18 44.1	—10 30	9.1— 9.7	0 11.9	4 1		21 21		3 19	21 15
κ Pavonis	18 46.6	—67 22	3.8— 5.2	9 02.2	4 16		22 20		11 1	29 5
U Aquilæ	19 24.0	— 7 15	6.2— 6.9	7 00.6	7 1		21 2		5 3	19 4
XZ Cygni	30.4	+56 10	8.6— 9.3	0 11.2	5 14		19 14		3 14	24 14
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	7 11		23 10		9 9	25 8
SU Cygni*	40.8	+29 01	6.2— 7.0	3 20.3	3 13		18 22		4 7	19 16
η Aquilæ	47.4	+ 0 45	3.7— 4.5	7 04.2	4 13		18 21		3 6	24 18
S Sagittæ	51.5	+16 22	5.6— 6.4	8 09.2	9 11		26 5		4 14	21 8
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	4 20		23 19		6 10	25 9
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3	1 0		17 10		3 19	20 4
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	3 23		17 6		5 0	18 7
UY Cygni	52.3	+30 03	9.6—10.4	0 13.5	3 18		23 23		7 9	20 20
RV Capric.	55.9	—15 37	9.2—10.1	0 10.7	4 16		18 2		8 5	21 16
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4	3 11		18 5		2 23	17 16
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	4 19		20 12		6 6	21 23
SW Aquarii	10.2	— 0 20	9.9—10.8	0 11.0	5 12		19 6		9 23	23 17
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	4 6		18 20		3 10	18 0
Y Lacertæ	22 05.2	+50 33	9.1— 9.6	4 07.8	1 8		18 15		5 23	23 6
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	6 0		22 3		8 5	24 7
Z Lacertæ	36.9	+56 18	8.2— 9.0	10 21.1	8 4		29 22		10 20	21 16
RR Lacertæ	37.5	+55 55	8.5— 9.2	6 10.1	1 20		21 2		3 22	23 4
V Lacertae	44.5	+55 48	8.5— 9.5	4 23.6	6 14		21 13		6 12	21 10
X Lacertæ	22 45.0	+55 54	8.2— 8.6	5 10.7	2 8		18 16		5 0	21 8
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	5 15		21 22		2 19	24 13
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	4 1		22 22		5 12	24 9
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4	6 17		18 20		13 3	25 7
V Cephei	23 51.7	+82 38	6.0— 7.0	0 23.9	6 16		20 15		4 14	18 14

Monthly Report of the American Association of Variable Star Observers, April 20 to June 20, 1922.

The present report is a very satisfactory one, and is made interesting by the fact that the three irregular variables, SS Cygni, 213843, SS Aurigae, 060547, and U Geminorum, 074922, were all at or near maximum on J. D. 3174. All of these stars, as well as R Coronae Borealis, 154428, deserve careful watching. Naked eye observations of Beta Lyrae for the next few months, made by observers experienced either in the Argelander or direct estimate method, are much desired and those desiring to observe this variable once a night should request Harvard Observatory to furnish them with charts.

The Council has elected Dr. George E. Hale, Director of the Mount Wilson Observatory, a Patron of the Association.

The following have been recently elected to active membership in the Association:

W. H. Christie, Victoria, B. C.
A. N. Cowperthwaite, Tucson, Ariz.
E. C. Glover, Boston, Mass.
W. H. Gruening, New York, N. Y.
T. S. Jacobsen, Palo Alto, Cal.
Miss Lillias A. Joy, St. Paul, Minn.
Sigeru Kanda, Tokyo, Japan.

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1922.

April 0 = J. D. 2423145 May 0 = J. D. 2423175 June 0 = J. D. 2423206

Star	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.
001046 X ANDROMEDAE—								
	3157.7	13.2 Wf,	3164.9	13.3 Wf,	3174.9	13.3 Wf,	3189.9<13.0 Wf,	
	3196.9<13.0 Wf,		3204.9	14.2 Wf.				
001755 T CASSIOPEIAE—								
	3130.1	8.4 Ch,	3151.6	8.1 L,	3160.4	8.4 Gi,	3177.6	8.7 L,
	3181.8	8.0 Pt,	3182.8	9.0 M,	3192.6	8.3 Gi,	3198.8	8.5 M,
	3199.6	8.1 L,	3202.8	7.8 Pt,	3203.6	8.0 Gi,	3220.8	7.7 M.
001838 R ANDROMEDAE—								
	3164.9	9.9 Wf,	3174.9	10.0 Wf,	3181.8	11.1 Pt,	3189.9	11.5 Wf,
	3196.9	11.8 Wf,	3201.2	11.3 Ym,	3202.8	11.5 Pt,	3204.9	11.9 Wf.
003179 Y CEPHEI—								
	3177.7	10.8 Mi,	3205.8	11.0 M.				
004047 U CASSIOPEIAE—								
	3157.7<12.8 Wf,		3164.9<14.0 Wf,		3174.9<14.0 Wf,		3189.9<12.8 Wf,	
	3196.9<12.8 Wf,		3204.9	14.0 Wf.				
004533 RR ANDROMEDAE—								
	3189.9<12.2 Wf,		3204.9	14.3 Wf.				
004958 W CASSIOPEIAE—								
	3160.4	8.7 Gi,	3181.8	9.7 Pt,	3182.8	9.9 M,	3197.6	9.9 Gi,
	3202.8	10.8 M,	3202.8	10.2 Pt.				
010940 U ANDROMEDAE—								
	3164.9	11.9 Wf,	3174.9	11.3 Wf,	3189.9	10.1 Wf,	3204.9	9.6 Wf,
	3219.8	10.0 M.						
011041 UZ ANDROMEDAE—								
	3204.9	12.4 Wf,	3219.8	10.9 M.				
011272 S CASSIOPEIAE—								
	3164 8	10.6 Wf,	3166.6	11.2 Pt,	3174.9	10.7 Wf,	3189.9	11.3 Wf,
	3197.8	11.4 Wf,	3202.8	11.8 Pt,	3202.8	11.5 M,	3204.9	11.5 Wf.
012350 RZ PERSEI—								
	3173.6	8.9 Y.						
013238 RU ANDROMEDAE—								
	3130.1	10.5 Ch,	3202.8	12.3 Pt,	3204.9	12.1 Wf.		
013338 Y ANDROMEDAE—								
	3130.1<11.0 Ch,		3202.8	9.6 Pt.				
014958 X CASSIOPEIAE—								
	3166.6	10.0 Pt,	3173.6	10.3 Y,	3182.8	10.6 M,	3202.8	11.0 M,
	3202.8	10.4 Pt.						
015354 U PERSEI—								
	3162.7	9.2 Mu,	3166.6	9.2 Pt,	3202.8	9.1 Pt,	3202.8	9.2 M.
021143a W ANDROMEDAE—								
	3159.3<12.5 Gi,		3165.7<12.9 Wf,		3174.7<11.8 Wf,		3204.9	12.9 Wf.
021258 T PERSEI—								
	3107.0	9.3 Jk.						
021281 Z CEPHEI—								
	3188.7	11.3 Br,	3201.8	11.6 Wf.				
021403 o CETI—								
	3128.1	6.9 Ch.						
021558 S PERSEI—								
	3020.0	9.7 Jk,	3107.0	9.5 Jk,	3142.9	9.5 Jk.		
022150 RR PERSEI—								
	3173.6	10.6 Y,	3201.8	11.7 Wf.				
022813 U CETI—								
	3129.1	7.8 Ch.						
022980 RR CEPHEI—								
	3154.3<13.0 L,		3160.3<14.0 L,		3164.7	13.7 Wf,	3174.7	13.5 Wf,
	3189 9	12.8 Wf,	3194.4	12.2 L,	3197.8	12.0 Wf,	3204.4	11.4 L,
	3204.9	11.8 Wf.						
023133 R TRIANGULI—								
	3136.9	8.6 Kd,	3142.9	9.0 Kd.				

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
024356 W PERSEI—												
	3153.7	8.6	Jb,	3160.6	8.8	Jb,	3162.7	8.6	Mu,	3166.6	9.0	Pt,
	3167.7	8.7	Jb,	3179.6	8.7	Jb,	3202.8	8.9	Pt,	3220.8	9.0	M.
032043 Y PERSEI—												
	3150.5	9.8	Hs,	3150.5	9.9	Cs,	3162.7	10.1	Mu,	3166.6	9.7	Pt,
	3202.8	8.3	Pt.									
032335 R PERSEI—												
	3158.3	11.2	Gi.									
042215 W TAURI—												
	3162.6	12.4	B.									
043065 T CAMELOPARDALIS—												
	3153.4	8.9	L,	3166.6	8.7	Pt,	3177.6	8.8	L,	3204.4	8.0	L.
	3225.7	7.1	Pt.									
043274 X CAMELOPARDALIS—												
	3130.1	10.0	Ch,	3138.1	11.2	Ch,	3157.6	12.3	Y,	3163.0	<12.3	Jk,
	3163.1	<11.7	Ch,	3166.6	11.9	Pt,	3202.6	9.8	Y,	3204.7	9.0	Br,
	3225.7	8.0	Pt.									
044617 V TAURI—												
	3165.7	12.3	Wf.									
045307 R ORIONIS—												
	3159.3	12.1	Gi,	3167.6	<12.0	Y.						
045514 R LEPORIS—												
	3130.1	10.3	Ch,	3151.3	9.9	L,	3159.1	9.9	Ch.			
050003 V ORIONIS—												
	3162.6	<12.5	B.									
050953 R AURIGAE—												
	3159.6	13.5	Lv.									
052034 S AURIGAE—												
	3154.4	10.4	L,	3166.6	10.0	Pt,	3167.3	9.6	Jp,	3167.3	9.4	Dp,
	3168.3	9.2	Jp,	3168.3	9.2	Dp,	3175.3	9.6	Jp,	3175.3	9.4	Dp,
	3194.4	9.6	L.									
052036 W AURIGAE—												
	3153.4	9.2	L,	3158.4	9.1	Gi,	3166.6	9.5	Pt,	3182.3	9.6	L,
	3183.4	9.6	Gi,	3194.4	10.3	L,	3196.6	10.5	Pt,	3198.4	10.4	Gi.
052404 S ORIONIS—												
	3160.7	10.8	Jb,	3174.6	11.5	B.						
053005a T ORIONIS—												
	3112.3	10.5	Pe,	3154.3	10.2	L,	3156.3	10.4	L,	3160.3	10.9	L,
	3160.7	10.4	Jb,	3166.6	10.1	Pt,	3167.7	9.9	Jb,	3168.3	9.9	Jp,
	3168.3	9.7	Dp,	3173.6	10.0	Pt,	3174.6	10.0	B.			
053068 S CAMELOPARDALIS—												
	3166.6	9.9	Pt,	3202.6	10.2	Pt.						
053531 U AURIGAE—												
	3155.6	<11.4	Hs,	3166.6	10.0	Pt,	3168.5	9.6	M,	3171.6	9.4	B,
	3172.6	9.6	Y,	3196.6	8.9	Pt.						
054319 SU TAURI—												
	3117.2	9.6	Ch,	3143.0	9.4	Jk,	3144.2	9.7	Ch,	3156.4	9.5	L,
	3157.7	9.5	Wf,	3159.1	9.6	Ch,	3160.4	9.4	L,	3160.7	9.4	Wf,
	3160.7	9.3	Jb,	3161.7	9.2	Jb,	3162.9	<10.1	Jk,	3164.7	9.5	Wf,
	3165.7	9.4	Wf,	3166.6	9.5	Pt,	3166.7	9.3	Jb,	3167.3	9.5	Jp,
	3167.3	9.6	Dp,	3167.6	9.7	Y,	3167.6	9.4	Pc,	3167.7	9.4	Wf,
	3167.7	9.3	Jb,	3168.3	9.4	Jp,	3168.3	9.4	Dp,	3168.5	9.5	L,
	3168.7	9.4	Wf,	3170.3	9.5	L,	3171.6	9.5	B,	3171.7	9.5	Wf,
	3173.6	9.5	Pt,	3174.7	9.4	Wf,	3175.3	9.5	Dp,	3175.3	9.4	Jp,
	3175.6	9.5	Pc,	3175.7	9.4	Wf,	3176.6	9.6	Cl,	3177.7	9.4	Wf,
	3182.3	9.5	L,	3182.6	9.5	Pc,	3183.3	9.5	Jp,	3183.3	9.6	Dp,
	3187.3	9.4	Jp,	3187.3	9.6	Dp,	3187.7	9.4	Wf,	3188.3	9.5	Jp,
	3188.3	9.5	Dp,	3188.6	9.5	Pt.						
054615a Z TAURI—												
	3167.3	11.3	Jp,	3167.3	11.3	Dp.						

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1922—Continued.

Star	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.
054615c RU TAURI—								
	3167.3	13.1 Jp.	3167.3	13.0 Dp.				
054920a U ORIONIS—								
	3117.2	12.2 Ch.	3130.2<12.2	Ch.	3144.2	12.1 Ch.	3159.1	12.0 Ch.
	3159.6	11.8 Lv.	3160.7	12.0 Jb.	3166.6	12.4 Pt.	3166.7	11.4 Jb.
	3174.6	10.4 B.						
054920b UW ORIONIS—								
	3159.6	10.6 Lv.						
054974 V CAMELOPARDALIS—								
	3164.7	14.0 Wf.	3167.6<12.6	Y.	3174.7	14.2 Wf.	3187.7<13.7	Wf.
	3194.5<14.0	Gi.	3197.8<13.2	Wf.	3202.6<12.6	Y.	3204.8<12.2	Br.
	3204.8<14.2	Wf.						
055353 Z AURIGAE—								
	3164.7	10.0 Wf.	3166.6	10.1 Pt.	3174.7	10.2 Wf.	3175.6	10.2 M.
	3189.7	10.8 Wf.	3196.6	10.8 Pt.	3197.8	11.0 Wf.	3204.7	10.9 Wf.
	3216.7	10.9 Wf.						
060450 X AURIGAE—								
	3119.2	8.9 Ch.	3131.1	8.8 Ch.	3138.1	8.7 Ch.	3150.5	8.9 Hs.
	3150.5	8.8 Cs.	3160.1	9.1 Ch.	3166.6	9.8 Pt.	3168.5	9.8 M.
	3169.6	10.4 Hs.	3169.6	10.9 Cs.	3171.6	10.3 B.	3175.3	10.4 Ro.
	3189.3	11.1 Ro.	3196.6	11.9 Pt.				
060547 SS AURIGAE—								
	31172	12.4 Ch.	3118.1	11.1 Ch.	3119.2	10.9 Ch.	3123.2	10.9 Ch.
	3129.1	12.4 Ch.	3131.2<12.4	Ch.	3153.4<12.4	L.	3154.3<13.3	L.
	3156.4<13.3	L.	3158.3<14.0	L.	3158.4<13.8	Gi.	3159.4<13.9	Gi.
	3160.1<12.4	Ch.	3160.3	15.0 L.	3160.4<12.4	Gi.	3166.3<13.0	Jp.
	3166.3<13.0	Dp.	3166.6<12.6	Pt.	3167.3<13.3	Jp.	3167.3<13.3	Dp.
	3167.6<13.3	Y.	3167.6<13.3	B.	3167.6<13.6	Pc.	3168.3<13.3	Jp.
	3168.3<13.3	Dp.	3168.4<14.0	L.	3168.5<12.4	M.	3168.7<12.0	Pt.
	3170.3<14.0	L.	3170.6<13.0	Y.	3171.0<12.4	Ym.	3172.4	11.3 Gi.
	3172.6	10.9 Y.	3173.6	11.0 Y.	3173.6	11.4 Pt.	3173.8	11.1 Wf.
	3174.7	11.8 Pt.	3174.7	11.7 Wf.	3175.3	12.2 Jp.	3175.3	12.3 Dp.
	3175.6	12.0 Pt.	3175.6	12.0 M.	3175.6	12.5 Fn.	3175.6	12.4 Pc.
	3175.7	12.2 Wf.	3176.5<11.0	Cl.	3178.3<13.0	Jp.	3178.3<13.0	Dp.
	3179.4<12.4	L.	3182.3<13.3	L.	3182.6<13.1	Pc.	3183.3<13.0	Jp.
	3183.3<13.0	Dp.	3183.4<12.4	Gi.	3185.3<12.4	Jp.	3185.3<12.4	Dp.
	3185.4<12.4	Gi.	3186.6<12.6	Pt.	31867<11.0	Pt.	3187.3<13.0	Jp.
	3187.3<13.0	Dp.	3187.7<14.5	Wf.	3188.0<12.4	Ym.	3188.3<13.0	Jp.
	3188.3<13.0	Dp.	3188.3<13.6	L.	3188.7<11.6	Br.	3188.7<12.4	Jb.
	3189.3<13.0	Jp.	3189.3<130	Dp.	3189.6	13.5 M.	3189.8<14.9	Wf.
	3190.6<12.6	Pt.	3194.4<14.0	L.	3194.4<13.8	Gi.	3194.7<13.9	Wf.
	3195.4<14.5	L.	3195.7<11.6	Jb.	3196.4<13.8	Gi.	3196.6<12.6	Pt.
	3197.4<13.8	Gi.	3197.4<13.3	L.	3197.8<12.3	Wf.	3198.0<12.4	Ym.
	3198.4<13.8	Gi.	3198.4<14.5	L.	3199.3<12.9	L.	3199.4<13.8	Gi.
	3201.7<13.9	Wf.	3202.6<12.6	Pt.	3202.6<13.0	Y.	3203.4<13.5	Gi.
	3203.7<11.2	Jb.	3203.8<13.3	Wf.	3204.4<13.3	L.	3204.6<11.0	Pt.
	3204.7<13.3	Wf.	3205.7<13.9	Wf.	3206.0<12.4	Ym.	3206.4<12.4	L.
	3209.6<12.4	Pc.	3216.8<12.3	Y.	3217.6<11.0	Pt.	3218.6<12.4	Pt.
061647 V AURIGAE—								
	3168.6	11.6 M.						
061702 V MONOCEROTIS—								
	3166.6	10.0 Pt.						
063159 U LYNCIS—								
	3173.6<13.6	Y.	3202.6	12.9 Y.				
063308 R MONOCEROTIS—								
	3166.6	11.0 Pt.	3167.6	11.6 B.				
063558 S LYNCIS—								
	3173.7<13.2	Mi.	3188.7<11.9	Br.	3209.7	<9.9 Br.	3218.6	12.1 Pt.
064030 X GEMINORUM—								
	3158.4	9.4 Gi.	4167.6	8.9 B.	3169.6	8.7 Hs.	3169.6	8.4 Cs.
	3185.6	8.2 Hs.	3185.6	8.3 Cs.	3194.4	8.5 Gi.	3197.6	8.6 Hs.

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
061707 W MONOCEROTIS—												
	3166.6	10.5	Pt.									
064932 NOVA GEMINORUM #2—												
	3160.4	13.8	L.									
065111 Y MONOCEROTIS—												
	3159.6	11.3	Lv,	3167.3	11.8	Jp,	3167.3	11.9	Dp,	3170.6	12.0	B,
	3183.3	12.1	Jp,	3183.3	11.9	Dp.						
065208 X MONOCEROTIS—												
	3154.3	7.7	L,	3167.3	8.1	Jp,	3167.3	7.9	Dp,	3168.3	8.0	Jp.
	3168.3	8.1	Dp,	3175.3	7.9	Jp,	3175.3	7.7	Dp.			
065355 R LYNCIS—												
	3158.5	10.1	Gi,	3164.7	10.1	Wf,	3168.6	10.5	M,	3171.6	9.6	B,
	3173.6	9.7	Y,	3174.7	9.5	Wf,	3183.4	9.0	Gi,	3187.7	8.7	Wf,
	3194.5	8.6	Gi,	3194.7	8.3	Wf,	3202.6	8.4	Y,	3205.8	8.1	Wf,
	3216.7	7.5	Wf.									
070109 V CANIS MINORIS—												
	3167.6	<13.0	B,	3171.6	<13.4	B,	3187.3	<11.4	Jp,	3187.3	<11.4	Dp.
070122a R GEMINORUM—												
	3133.2	10.2	Ch,	3143.0	<11.1	Jk,	3159.7	11.1	Lv,	3160.1	11.5	Ch.
	3166.6	12.2	Pt,	3171.6	11.6	B,	3175.6	12.6	Hu.			
070122b Z GEMINORUM—												
	3133.2	<11.5	Ch,	3143.0	<11.1	Jk,	3159.7	12.3	Lv,	3166.6	12.7	Pt.
	3171.6	12.4	B,	3196.6	12.6	Pt.						
070122c TW GEMINORUM—												
	3143.0	8.4	Jk,	3159.7	8.3	Lv,	3171.6	8.3	B.			
070310 R CANIS MINORIS—												
	3154.3	9.5	L,	3167.6	9.2	B,	3179.4	9.9	L,	3185.5	9.5	Gd,
	3188.6	9.5	B,	3194.3	10.3	L.						
071044 U_2 PUPPIS—												
	3136.1	3.8	Ch,	3144.1	4.0	Ch.						
071201 RR MONOCEROTIS—												
	3159.7	<13.2	Lv.									
071713 V GEMINORUM—												
	3166.6	10.4	Pt,	3175.6	9.6	Ya,	3183.6	9.0	B,	3185.6	9.1	Gd,
	3196.6	8.7	Pt.									
072708 S CANIS MINORIS—												
	3112.3	10.3	Pc,	3133.2	10.0	Ch,	3144.2	9.9	Ch,	3154.3	9.7	L,
	3163.2	9.5	Ch,	3166.6	9.5	Pc,	3166.6	9.3	Pt,	3166.7	9.0	Jb,
	3168.3	9.4	Jp,	3168.3	9.4	Dp,	3170.6	9.0	B,	3171.5	9.1	Ya,
	3175.6	8.6	M,	3179.4	8.7	L,	3185.3	8.3	Jp,	3185.3	8.3	Dp,
	3185.6	8.6	O,	3188.7	8.6	Jb,	3194.3	8.1	L,	3195.7	8.8	Jb,
	3196.6	8.3	Pt.									
072811 T CANIS MINORIS—												
	3136.9	11.3	Kd,	3142.9	11.9	Kd,	3166.7	12.0	Pt,	3167.6	13.4	B,
	3175.6	<11.8	M,	3187.3	<11.8	Jp,	3189.3	<12.4	Dp.			
073508 U CANIS MINORIS—												
	3154.3	12.6	L,	3167.6	12.7	B,	3172.6	<12.0	Y,	3175.6	<11.9	M,
	3188.3	12.7	L,	3195.4	<12.4	L.						
073723 S GEMINORUM—												
	3142.9	12.2	Kd,	3166.3	13.1	Jp,	3166.3	13.0	Dp,	3166.7	12.6	Pt,
	3167.6	12.9	B,	3173.7	13.5	Mi.						
074323 T GEMINORUM—												
	3136.0	9.3	Kd,	3139.0	9.2	Kd,	3142.9	9.4	Kd,	3159.9	10.9	Kd,
	3162.9	10.7	Kd,	3166.3	10.9	Jp,	3166.3	10.7	Dp,	3173.7	11.4	Mi,
	3175.6	11.3	Ya,	3187.6	12.3	B.	3189.3	12.1	Jp,	3189.3	12.2	Dp.
074922 U GEMINORUM—												
	3107.0	<10.9	Jk,	3117.2	<12.4	Ch,	3143.0	<11.7	Jk,	3153.4	<12.4	L,
	3154.3	<13.3	L,	3156.0	<12.4	Ym,	3156.3	<12.4	L,	3157.7	14.1	Wf,
	3158.3	<13.7	L,	3158.4	<13.8	Gi,	3159.4	14.0	Gi,	3160.3	14.2	L,
	3160.4	13.9	Gi,	3160.7	14.1	Wf,	3162.6	<13.7	B,	3163.0	<11.7	Jk,
	3163.6	<13.7	B,	3164.6	<13.8	B,	3164.7	14.1	Wf,	3165.7	14.0	Wf,

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
074922 U GEMINORUM—Continued.												
	3166.3	<13.3	Dp,	3166.3	<13.3	Jp,	3166.6	<13.7	Y,	3166.7	<12.4	Pt,
	3167.6	14.0	Pc,	3167.6	<13.8	B,	3167.7	14.1	Wf,	3168.3	<13.3	Dp,
	3168.3	<13.3	Jp,	3168.4	<13.7	L,	3168.7	13.8	Wf,	3168.7	<11.8	Pt,
	3169.6	9.4	Ya,	3169.6	10.7	B,	3169.8	9.7	Wf,	3170.3	9.3	L,
	3170.6	9.8	B,	3170.6	9.7	Y,	3170.8	9.6	Wf,	3171.0	9.4	Ym,
	3171.2	9.2	Ch,	3171.6	9.8	B,	3171.7	9.5	Wf,	3172.0	9.2	Ym,
	3172.6	9.6	Y,	3172 6	9.7	B,	3173.0	9.4	Ym,	3173.6	9.5	Y,
	3173.6	9.4	Pt,	3173.7	9.5	Wf,	3174.6	9.8	B,	3174.7	9.2	Pt,
	3174.7	93	Wf,	3175.3	9.7	Dp,	3175.3	9.6	Jp,	3175.6	9.1	M,
	3175.6	9.4	Pt,	3175.6	9.5	Pc,	3175.6	9.3	Fn,	3175.7	9.2	Wf,
	3176.6	9.5	Y,	3177.7	9.8	Wf,	3178.3	10.2	Dp,	3178.3	10.0	Jp,
	3179.4	10.2	L,	3179.6	10.6	B,	3181.6	11.8	B,	3182.4	12.5	L,
	3182.6	12.6	B,	3182.7	12.8	Pc,	3183.4	<12.7	Gi,	3183.6	<12.8	B,
	3183.6	<10.9	O,	3183.6	<12.4	Y,	3184.8	<12.3	Wf,	3185.3	<12.7	Gi,
	3185.6	<10.9	O,	3186.7	<11.3	Pt,	3187.3	<13.3	Jp,	3187.3	<13.3	Dp,
	3187.7	13.8	Wf,	3188.0	<12.4	Ym,	3188.3	<13.3	Jp,	3188.3	<13.3	Dp,
	3188.6	<13.7	B,	3188.6	<13.3	Pt,	3188.7	<11.7	Br,	3189.3	<13.3	Jp,
	3189.3	<13.3	Dp,	3189.6	12.8	M,	3189.7	13.9	Wf,	3189.7	<11.3	Pt,
	3190.6	<12.4	Pt,	3194.4	<13.3	L,	3194.4	<13.7	Gi,	3194.6	<10.9	O,
	3194.7	<13.7	Wf,	3195.4	<13.7	L,	3195.7	<12.4	Jb,	3196.4	13.9	Gi,
	3196.6	<12.4	Pt,	3197.4	<13.7	Gi,	3197.4	<13.7	L,	3197.8	<12.3	Wf,
	3198.0	<12.4	Ym,	3198.4	<13.7	Gi,	3199.4	<13.7	Gi,	3201.7	<13.7	Wf,
	3202.6	<12.4	Pt,	3202.6	<13.3	Y,	3202.6	<12.4	O,	3203.4	<13.7	Gi,
	3203.6	<10.9	O,	3203.7	<12.3	To,	3203.7	<12.4	Jb,	3203.8	<12.3	Wf,
	3204.0	<12.4	Ym,	3204.4	<13.3	L,	3204.6	<11.3	Pt,	3204.7	<12.3	Wf,
	3205.7	<12.3	Wf,	3206.0	<12.4	Ym.						
075612 U PUPPIS—												
	3167.6	<13.0	Y.									
081112 R CANCRI—												
	3124.1	7.0	Ch,	3139.2	6.8	Ch,	3150 2	6.8	Ch,	3153.4	7.3	L,
	3160.7	8.2	Jb,	3166.7	7.6	Pt,	3167.7	8.1	Jb,	3171.2	7.7	Ch,
	3174.6	8.2	Ya,	3175.6	8.2	M,	3182.3	8 2	L,	3183.6	8.2	B,
	3188.7	8.6	Jb,	3194.4	8.4	L,	3194.6	8.6	O,	3195.7	8.7	Jb,
	3196.6	8.6	Pc,	3196.6	8.5	Pt,	3202.7	9.0	Jb,	3204.4	8.7	L.
081617 V CANCRI—												
	3158.4	10.1	Gi,	3166.7	11.1	Pt,	3170.6	11.1	B,	3175.6	11.8	M,
	3188.7	<11.3	Br,	3194.4	11.8	Gi,	3195.6	12.1	B.			
081633 T LYNCIS—												
	3175.6	10.3	Hu.									
082405 RT HYDRAE—												
	3158.4	7.4	L,	3166.4	7.9	Jp,	3166.4	8.0	Dp,	3168.3	7.7	Jp,
	3168.3	7.9	Dp,	3172.6	7.4	B,	3173.6	7.2	Pt,	3175.3	7.7	Jp,
	3175.3	7.8	Dp,	3175.6	7.6	Ya,	3182.3	7.9	L.	3189.3	8.0	Jp,
	3189.3	8.0	Dp,	3194.3	7.9	L,	3196.6	7.6	Pt.			
083019 U CANCRI—												
	3159.7	<13.3	Lv,	3160.8	13.8	Wf,	3166.4	<13.3	Jp,	3166.4	<13.3	Dp,
	3174.7	13.9	Wf,	3175.6	<11.9	M,	3187.7	13.6	Wf,	3194.7	13.2	Wf,
	3202.6	12.5	O,	3204.7	12.7	Wf.						
083350 X URSAE MAJORIS—												
	3165.7	13.7	Lv,	3174.7	<13.5	Lv.	3195.6	<13.7	B,	3206.7	<13 6	Lv,
084803 S HYDRAE—												
	3129.1	8.4	Ch,	3139.1	8.7	Ch,	3159.1	8.3	Ch,	3166.4	8.0	Jp.
	3166.4	8.1	Dp,	3168.3	7.9	Jp,	3168 3	7.9	Dp,	3170.1	8.1	Ch,
	3173.6	8.0	Pt,	3175.6	7.9	Hu,	3175.6	8.0	M,	3175.6	8.0	Ya.
	3187.4	8.0	Jp.	3187.4	7.8	Dp.	3188.6	8.2	B.	3196.6	8.6	Pt.
085008 T HYDRAE—												
	3129.1	8.8	Ch,	3139.1	8.5	Ch,	3153.4	7.7	L,	3159 1	7.5	Ch,
	3170.2	7.5	Ch.	3172.6	7.7	B.	3173.6	7.4	Pt.	3182.3	7.8	L,
	3194.3	7.8	L,	3195.6	7.8	Gd.	3196.6	7.8	Pt.			

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1922—Continued.

Star	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.
085120 T CANCRI—								
	3154.4	8.8 L,	3172.6	8.6 B,	3173.6	8.0 Pt,	3175.6	9.0 M,
	3194.4	7.9 L,	3196.6	8.0 Pt,	3204.4	8.0 L		
090024 S PYXIDIS—								
	3143.0	9.5 Kd,	3159.9	9.9 Kd,	3162.9	10.1 Kd,	3173.6	9.7 Pt.
090151 V URSAE MAJORIS—								
	3179.6	10.1 B,	3187.4	10.2 Pe,	3189.6	9.8 Hu.		
090425 W CANCRI—								
	3160.4	13.1 L,	3160.8	13.5 Wf,	3172.6	13.8 B,	3174.7	13.8 Wf,
	3187.7	13.9 Wf,	3188.4<13.7 L,		3194.4	14.2 L,	3194.7	14.1 Wf,
	3203.8	14.3 Wf.						
093014 X HYDRAE—								
	3173.6	12.7 Pt,	3195.6	12.7 B.				
093178 Y DRACONIS—								
	3167.6<13.9 Y,		3188.8<12.0 Br,		3202.6	13.6 Y.		
093934 R LEONIS MINORIS—								
	3118.1	7.4 Ch,	3129.1	7.5 Ch,	3139.1	7.7 Ch,	3151.6	7.8 L,
	3163.2	8.2 Ch,	3166.4	8.3 Jp,	3166.4	8.2 Dp,	3173.6	8.4 Pt,
	3173.6	8.8 Pc,	3174.6	8.8 Ya,	3175.6	8.4 Hu,	3181.6	8.8 B,
	3185.4	8.8 Jp,	3185.4	9.0 Dp,	3188.4	8.9 L,	3196.6	9.6 M,
	3196.6	8.8 Pt,	3197.6	9.5 Gd,	3198.4	9.3 L,	3203.6	9.4 Hu.
094211 R LEONIS—								
	3112.3	8.7 Pe,	3118.2	8.3 Ch,	3128.1	8.7 Ch,	3138.1	9.4 Ch,
	3136.2	9.8 Ch,	3156.3	9.9 An,	3160.7	9.5 Sg,	3166.4	9.4 Jp,
	3166.4	9.4 Dp,	3168.7	9.8 Sg,	3171.0	9.9 Ym,	3172.0	9.8 Ym,
	3173.1	9.8 Ym,	3173.6	9.4 Pt,	3173.6	9.8 Pc,	3174.4	8.9 Pe,
	3174.6	9.9 Ya,	3175.3	9.8 Ro,	3176.5	9.5 Cl,	3177.8	9.6 Sg,
	3185.6	9.6 Gd,	3187.4	9.6 Jp,	3187.4	9.5 Dp,	3188.7	9.5 Sg,
	3189.3	9.0 Ro,	3194.3	10.1 An,	3195.8	9.5 Sg,	3196.6	10.0 M,
	3196.6	9.6 Pt,	3198.0	9.8 Ym,	3199.6	9.7 Jn,	31996	9.7 Kg,
	3202.7	9.9 Pc,	3202.7	9.6 Su,	3203.6	9.8 O,	3204.0	10.1 Ym,
	3204.7	9.5 Sg,	3206.4	9.6 An,	3220.7	9.0 Sg.		
094512 X LEONIS—								
	3154.3	12.1 L,	3156.3	13.0 L,	3158.3<13.8 L,		3160.3<14.0 L,	
	3168.4<13.3 L,		3170.3<13.3 L,		3171.0<13.3 Ym,		3172.1<12.3 Ym,	
	3173.0<12.3 Ym,		3188.4<12.5 L,		3194.4	12.1 L,	3195.4	12.2 L,
	3197.3	13.3 L.	3198.0<12.3 Ym,		3204.0<12.3 Ym,		3204.4<13.3 L,	
	3206.0<12.4 Ym,		3206.4<12.3 L.					
094622 Y HYDRAE—								
	3166.4	6.6 Jp,	3166.4	6.8 Dp,	3168.4	6.4 Jp,	3168.4	6.7 Dp,
	3173.6	6.1 Pt,	3175.3	6.7 Jp,	3175.3	6.9 Dp.		
095421 V LEONIS—								
	3159.6<13.3 Lv,		3160.8	13.7 Wf,	3167.7	13.3 Lv,	3172.6	13.5 B,
	3173.6	12.8 Pt,	3174.7	13.6 Wf,	3174.7	13.4 Lv,	3187.7	13.6 Wf,
	3194.7	13.6 Wf,	3196.6	12.7 Pt,	3196.6<11.8 M,		3203.8	13.6 Wf,
	3206.7<12.8 Lv.							
103212 U HYDRAE—								
	3165.0	5.4 Kd,	3170.3	5.4 L,	3195.4	4.9 L.		
103769 R URSAE MAJORIS—								
	3118.2<11.5 Ch,		3144.1<11.5 Ch,		3162.8	12.7 Lv,	3167.6	12.7 Pc,
	3168.6	11.6 Hj,	3168.6<12.0 M,		3173.6	13.0 Pt,	3173.7	11.7 Hj,
	3174.7	12.7 Lv,	3175.7<11.5 Hj,		3188.8<12.0 Br,		3189.3	12.2 Ro,
	3194.7	12.3 Lv,	3195.6	12.3 B,	3195.8	11.5 Sg,	3196.6	12.3 Pt,
	3196.6	11.9 Pc,	3201.7	12.1 Lv,	3203.6	12.3 M,	3204.6	11.8 O,
	3204 9	12.0 Br,	3205.7<11.5 Hj,		3218.7 <9.9 Lc,		3220.8	12.0 Sg,
	3228.7<10.0 Lc.							
104620 V HYDRAE—								
	3118.2	8.5 Ch,	3133.2	8 8 Ch,	3156.4	8.1 L,	3159.1	8.8 Ch,
	3173.6	8.4 Pt.	3195.4	9.2 L,	3196.7	9.0 Pt,	3197.6	9.3 Gd.
104814 W LEONIS—								
	3159.7	11.0 Lv,	3166.4	10.9 Jp,	3166.4	10.8 Dp,	3166.6	11.0 Y,

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
104814 W LEONIS—Continued.												
	3173.6	11.2	Pt,	3174.7	11.6	Lv,	3184.6	12.0	Lv,	3186.4	11.6	Jp,
	3186.4	11.4	Dp,	3188.6	11.8	B,	3196.6	12.2	M,	3196.7	12.1	Pt,
	3201.7	12.5	Lv,	3202.6	12.3	Y.						
110506 S LEONIS—												
	3173.7	12.9	Pt,	3188.6	13.1	B,	3196.6	<11.5	M.			
115905 RX VIRGINIS—												
	3140.4	8.3	Jp,	3140.4	8.3	Dp,	3166.4	8.3	Jp,	3166.4	8.1	Dp,
	3168.4	8.4	Jp,	3168.4	8.6	Dp,	3175.3	8.4	Jp,	3175.3	8.4	Dp.
	3189.3	8.4	Jp,	3189.3	8.5	Dp.						
115919 R COMAE BERENICES—												
	3162.6	13.0	B,	3162.7	13.3	Lv,	3164.8	12.7	Wf,	3165.7	12.7	Wf,
	3167.7	12.4	Wf,	3168.7	12.3	Wf,	3169.7	12.2	Wf,	3170.8	11.9	Wf,
	3171.7	11.9	Wf,	3172.6	11.8	B,	3173.8	11.7	Wf,	3174.6	11.3	Ya,
	3174.7	11.5	Wf,	3174.7	11.5	Lv,	3175.7	11.4	Wf,	3177.8	11.3	Wf,
	3184.6	9.8	Lv,	3184.8	9.5	Wf,	3185.7	9.6	Wf,	3187.7	9.3	Wf,
	3188.7	9.5	Br,	3189.8	9.1	Wf,	3190.6	9.2	Pt,	3194.7	9.1	Wf,
	3194.7	9.3	Lv,	3195.6	9.4	Ya,	3196.7	9.1	Pt,	3196.7	9.1	Cd,
	3196.8	9.1	Wf,	3197.8	9.0	Wf,	3199.6	9.3	Hg,	3204.7	9.0	Br,
	3206.6	9.1	Lv,	3215.8	8.7	Wf,	3221.6	8.7	Wl.			
120012 SU VIRGINIS—												
	3173.7	12.7	Pt,	3174.6	13.2	B,	3196.6	<12.0	M,	3218.6	<13.0	B.
120206 RW VIRGINIS—												
	3140.4	7.1	Jp,	3140.4	7.2	Dp,	3166.4	7.3	Jp,	3166.4	7.4	Dp,
	3168.4	7.4	Jp,	3168.4	7.4	Dp,	3175.3	7.3	Jp,	3175.3	7.4	Dp,
	3189.4	7.3	Jp,	3189.4	7.2	Dp						
120905 T VIRGINIS—												
	3162.6	<13.4	B,	3174.7	<13.0	Lv,	3188.8	<11.8	Br,	3201.7	<12.8	Lv.
121418 R CORVI—												
	3156.4	7.3	L,	3168.6	7.8	M,	3168.7	7.3	Pt,	3171.1	8.4	Ym,
	3175.6	8.0	Ya,	3181.6	8.2	B,	3194.4	8.6	L,	3195.6	8.5	Gd,
	3195.6	8.8	Ya,	3196.6	9.2	M,	3196.7	9.0	Pt,	3198.0	9.1	Ym,
	3202.6	9.1	O,	3204.0	9.7	Ym,	3204.4	9.2	L,	3218.6	9.9	Gd.
122001 SS VIRGINIS—												
	3151.6	7.9	L,	3166.6	8.0	Hu,	3168.6	9.4	M,	3181.6	8.1	B,
	3194.4	7.7	L,	3196.6	9.8	M,	3203.6	8.0	Hu,	3204.4	7.6	L,
	3204.6	9.0	O.									
122532 T CANUM VENATICORUM—												
	3164.6	11.3	B,	3175.6	11.0	M,	3175.6	11.0	Ya,	3184.6	11.0	B,
	3186.7	11.3	Pt,	3188.8	11.2	Br,	3195.6	10.6	Ya,	3196.7	11.1	Pt,
	3198.6	11.5	M,	3204.8	11.1	Br,	3219.6	11.3	Wl.			
122803 Y VIRGINIS—												
	3151.6	12.0	L,	3174.6	13.3	B,	3174.7	<12.0	Ya,	3188.8	<11.1	Br,
	3190.6	<13.1	B,	3194.4	<14.0	L,	3196.6	<12.4	M,	3204.4	14.1	L,
	3218.6	<13.2	B.									
123160 T URSAE MAJORIS—												
	3112.3	10.7	Pe,	3130.1	<11.5	Ch,	3164.6	<13.1	B,	3166.4	<13.0	Jp,
	3166.4	<13.0	Dp,	3167.6	13.0	Pc,	3168.4	13.0	Jp,	3168.4	13.1	Dp,
	3171.1	12.6	Ym,	3175.3	13.2	Jp,	3175.3	13.2	Dp,	3184.6	<12.3	B,
	3188.8	<11.7	Br,	3189.6	12.6	Hu,	3196 6	13.2	Pc,	3198.0	<12.3	Ym,
	3201.0	13.3	Ym,	3203.6	12.8	M,	3204.8	<11.3	Br,	3213.6	<12.3	B,
	3220.7	13.2	Pt.									
123307 R VIRGINIS—												
	3151.6	11.4	L,	3162.1	10.2	Ch,	3166.4	10.2	Dp,	3166.4	10.3	Jp,
	3166.6	10.2	Hu,	3168.8	10.5	Pt,	3170.1	10.1	Ch,	3171.1	10.3	Ym,
	3175.6	9.9	Ya,	3177.5	10.2	L,	3177.6	10.0	Hs,	3177.6	9.7	Cs,
	3181.6	9.2	B,	3186.4	8.8	Jp,	3186.4	9.0	Dp,	3194.4	8.6	L,
	3195.6	8.5	Gd,	3195.6	8.6	Ya,	3196.6	8.5	M,	3196.7	8.4	Pt,
	3197.6	8.6	O,	3197.6	8.9	Hs,	3198.6	8.8	Hs,	3198 6	8.4	Cs,
	3199.0	8.7	Ym,	3201.1	8.8	Ym,	3203.6	8.4	Hu,	3204.0	8.3	Ym,
	3204.4	7.8	L,	3218.6	7.3	Gd,	3218.7	7.8	Lc,	3228.7	7.8	Lc.

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
123459 RS URSAE MAJORIS—												
	3130.1	<11.5	Ch,	3164.7	10.1	B,	3164.8	10.1	Wf,	3165.2	10.0	Ch,
	3165.7	10.1	Lv,	3166.6	10.0	Pc,	3168.6	9.8	M,	3168.8	9.7	Pt,
	3170.2	9.4	Ch,	3171.1	10.1	Ym,	3174.8	9.0	Lv,	3174.8	9.3	Wf,
	3176.5	9.1	Cl,	3184.6	8.6	B,	3185.6	8.7	Ya,	3187.8	8.6	Wf,
	3188.8	8.7	Br,	3194.7	8.6	Lv,	3194.7	8.5	Wf,	3196.6	9.0	M,
	3196.7	8.5	Pt,	3196.7	8.6	Pc,	3197.8	8.6	Sg,	3198.6	8.7	Ya,
	3198.0	8.6	Ym,	3199.0	9.1	Ym,	3201.0	9.0	Ym,	3201.8	8.6	Lv,
	3202.7	8.6	Su,	3203.7	8.6	Cd,	3203.8	8.6	Wf,	3205.7	8.6	Pc,
	3210.6	8.7	Gd,	3213.6	8.8	B,	3216.8	8.6	Wf,	3219.7	9.6	Lv,
	3220.8	8.4	Sg.									
123961 S URSAE MAJORIS—												
	3112.3	7.8	Pe,	3123.2	8.2	Ch,	3135.5	8.3	Ch,	3153.4	8.0	L,
	3159.2	8.3	Ch,	3162.6	8.2	B,	3163.7	8.5	Sg,	3164.6	9.2	B,
	3166.6	8.2	Pc,	3167.5	8.4	Dp,	3167.5	8.3	Jp,	3167.7	8.7	Sg,
	3168.6	8.7	M,	3168.8	8.6	Pt,	3170.2	8.6	Ch,	3174.8	8.8	Lv,
	3175.3	8.8	Ro,	3176.5	9.4	Cl,	3177.6	8.8	L,	3177.8	8.8	Sg,
	3185.6	9.4	Ya,	3186.4	9.1	Jp,	3186.4	9.2	Dp,	3187.8	9.2	Sg,
	3189.3	9.1	Ro,	3189.6	8.8	Hu,	3194.4	10.3	L,	3194.4	10.2	An,
	3195.7	10.0	Sg,	3196.6	10.4	M,	3196.7	10.0	Pc,	3196.7	10.2	Pt,
	3198.6	10.3	Ya,	3199.7	10.0	Sg,	3202.7	10.5	Su,	3202.7	10.1	Br,
	3204.4	10.4	L,	3205.6	10.0	Hu,	3205.7	10.8	Pc,	3206.7	10.3	Lv,
	3208.8	<10.1	Sg,	3210.6	10.8	Gd,	3213.6	10.6	B,	3216.4	10.9	Ro,
	3218.6	<8.8	Mc,	3220.8	12.0	Sg.						
124204 RU VIRGINIS—												
	3191.6	13.7	B,	3218.6	13.7	B.						
124606 U VIRGINIS—												
	3166.4	12.1	Jp,	3166.4	12.2	Dp,	3174.6	11.8	B,	3187.4	10.0	Jp,
	3187.4	10.2	Dp,	3190.6	9.8	Pt,	3191.6	10.0	B,	3196.7	9.4	Pt,
	3213.6	8.9	B.									
130212 RV VIRGINIS—												
	3164.8	<14.0	Wf,	3174.8	<13.3	Wf,	3187.7	<14.0	Wf,	3194.8	<13.6	Wf,
	3203.8	<13.6	Wf,	3217.8	<13.1	Wf.						
132002 W VIRGINIS—												
	3191.6	9.4	B,	3213.7	9.8	B.						
132202 V VIRGINIS—												
	3169.6	<13.0	B,	3191.6	10.3	B,	3213.6	13.3	B.			
132422 R HYDRAE—												
	3131.2	7.2	Ch,	3144.2	7.4	Ch,	3153.4	6.6	L,	3159.2	7.7	Ch,
	3159.4	7.7	Gi,	3168.8	7.5	Pt,	3171.2	8.2	Ch,	3183.5	7.7	Gi,
	3194.4	8.2	L,	3196.7	8.2	Pt,	3197.4	8.6	Gi,	3199.6	9.3	Q,
	3199.6	9.4	Kg,	3199.6	9.2	Hg,	3199.6	9.1	Ck,	3199.6	9.2	Jn,
	3204.4	9.0	L.									
132706 S VIRGINIS—												
	3117.2	7.6	Ch,	3131.2	7.8	Ch,	3144.2	7.9	Ch,	3161.7	8.6	Jb,
	3162.2	8.5	Ch,	3162.7	8.3	Mu,	3163.7	8.6	Sg,	3164.8	8.6	Wf,
	3166.6	8.6	Hu,	3167.7	8.7	Jb,	3168.8	8.8	Pt,	3171.2	8.8	Ch,
	3172.8	9.0	Sg,	3174.8	8.8	Wf,	3181.6	8.9	B,	3187.6	9.1	Ya,
	3187.8	9.1	Sg,	3187.8	9.1	Wf,	3188.8	8.8	Jb,	3194.8	9.3	Wf,
	3195.7	9.2	Sg,	3195.8	9.1	Jb,	3196.6	9.6	M,	3196.7	9.3	Pt,
	3198.0	9.1	Ym,	3198.6	9.2	Ya,	3202.8	9.6	Jb,	3203.8	10.6	Wf,
	3208.8	<9.4	Sg,	3216.8	10.2	Wf.						
133273 T URSAE MINORIS—												
	3164.8	13.2	Wf,	3167.8	13.5	Lv,	3174.8	13.2	Wf,	3187.8	12.9	Wf,
	3188.8	<12.1	Br,	3194.7	12.5	Lv,	3194.8	12.9	Wf,	3198.6	<11.5	Ya,
	3203.8	12.8	Wf,	3204.8	<11.4	Br,	3206.7	11.9	Lv,	3216.8	12.6	Wf.
133633 T CENTAURI—												
	3152.1	6.6	Kd,	3154.1	6.4	Kd,	3159.1	6.4	Kd,	3163.1	6.4	Kd,
	3170.0	6.7	Kd,	3172.0	6.8	Kd,	3180.0	6.9	Kd.			
134440 R CANUM VENATICORUM—												
	3164.6	7.6	B,	3168.8	7.1	Pt,	3175.6	7.4	M,	3184.6	8.0	B,

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
134440 R CANUM VENATICORUM—Continued.												
	3185.6	7.8	Ya,	3194.8	8.6	Lv,	3196.6	8.7	M,	3196.7	8.2	Pt,
	3198.6	8.4	Ya,	3201.8	8.3	Lv,	3206.8	8.3	Lv,	3219.8	9.1	Lv.
135908 RR VIRGINIS—												
	3168.8	12.0	Pt,	3189.6	13.4	M,	3196.7	12.9	Pt.			
140113 Z BOOTIS—												
	3164.8	11.0	Wf,	3167.6	11.0	Y,	3168.6	11.7	M,	3168.8	10.0	Pt,
	3174.8	10.6	Wf,	3186.6	12.7	B,	3196.6	12.0	M,	3202.6	12.8	Y.
140512 Z VIRGINIS—												
	3191.7	11.1	B,	3218.6	10.3	B,	3220.6	10.5	Pt.			
141567 U URSAE MINORIS—												
	3232.2	8.7	Ch,	3144.1	7.7	Ch,	3157.2	7.6	Ch,	3167.6	7.6	Pc,
	3167.8	8.4	Lv,	3168.6	8.0	M,	3168.8	7.3	Pt,	3169.6	7.9	B,
	3170.2	7.6	Ch,	3185.6	7.7	Ya,	3194.6	8.6	B,	3195.7	8.7	Lv,
	3198.8	8.2	M,	3199.7	8.3	Pt,	3202.6	7.8	Pw,	3204.6	8.1	Pw,
	3204.6	8.6	Ya,	3205.6	8.5	Hu,	3205.7	8.7	Pc,	3206.7	8.7	Lv.
141954 S BOOTIS—												
	3131.2<	11.6	Ch,	3151.6	12.9	L,	3158.5	12.7	Gi,	3162.2<	12.0	Ch,
	3164.7	12.4	B,	3167.6	12.0	Y,	3168.8	11.8	Pt,	3171.1	11.9	Ym,
	3173.1	12.0	Ym,	3177.6	11.9	L,	3183.5	10.9	Gi,	3187.6	10.8	Ya,
	3188.0	10.7	Ym,	3188.6	10.5	B,	3194.4	10.2	L,	3194.5	10.3	Gi,
	3198.1	10.2	Ym,	3199.7	10.0	Pt,	3201.0	10.0	Ym,	3204.4	9.7	L.
	3204.6	9.7	Gd,	3204.6	9.9	Ya,	3204.6	9.7	Y,	3204.6	9.8	Gi.
142205 RS VIRGINIS—												
	3168.6	9.2	M,	3169.6	7.4	B,	3188.6	8.0	B,	3195.6	8.4	Gd,
	3204.6	8.6	O,	3204.6	8.7	Ya,	3218.6	9.4	Gd.			
142539 V BOOTIS—												
	3167.6	7.2	Pc,	3167.7	7.5	Sg,	3168.6	7.4	Hj,	3168.8	7.0	Pt,
	3169.6	7.3	B,	3175.3	7.5	Ro,	3175.6	7.0	M,	3175.7	7.8	Hj,
	3177.6	8.0	Cs,	3177.6	8.0	Hs,	3177.6	7.8	L,	3180.3	7.6	Ro,
	3183.7	7.8	Mc,	3185.6	8.5	Hs,	3185.6	7.9	O,	3186.6	7.9	B,
	3187.6	7.7	Ya,	3188.7	8.3	Sg,	3189.3	8.1	Ro,	3189.6	7.9	Hu,
	3191.6	8.0	Hs,	3191.6	7.8	Cs,	3194.3	8.1	Ro,	3194.4	8.1	L,
	3196.7	8.4	M,	3196.7	8.5	Sg,	3197.6	8.3	Hs,	3197.8	8.5	Hj,
	3198.6	8.3	Cs,	3198.6	8.0	Cs,	3199.7	7.8	Pt,	3202.6	8.6	Pc,
	3202.7	9.1	Su,	3204.4	8.2	L,	3204.6	8.3	Gd,	3204.6	8.5	Ya,
	3205.6	8.2	Hu,	3205.7	8.6	Hj,	3216.4	8.7	Ro,	3219.6	9.2	Wl,
	3220.7	9.2	Sg.									
142584 R CAMELOPARDALIS—												
	3158.5	9.3	Gi,	3164.8	8.8	Wf,	3168.4	8.8	Dp,	3168.4	9.0	Jp,
	3173.7	8.9	Pt,	3174.8	8.6	Wf,	3175.4	8.8	Dp,	3175.4	8.8	Jp,
	3183.4	8.6	Gi,	3185.6	8.6	Ya,	3186.4	8.2	Jp,	3186.4	8.0	Dp,
	3187.8	8.5	Wf,	3188.8	8.3	Br,	3194.4	8.2	Gi,	3194.8	8.5	Wf,
	3196.7	8.2	M,	3199.0	8.6	Ym,	3199.7	7.9	Pt,	3201.1	8.6	Ym,
	3203.8	8.3	Wf,	3204.1	8.6	Ym,	3204.4	8.2	Gi,	3204.6	8.4	Ya,
	3206.1	8.7	Ym,	3213.6	8.2	B,	3216.8	8.2	Wf.			
143227 R BOOTIS—												
	3132.2	11.5	Ch,	3162.2	11.5	Ch,	3168.7<	10.5	Sg,	3173.7	12.6	Pt,
	3174.6	12.3	B,	3188.8<	11.7	Br,	3189.6	11.6	M,	3194.6	11.6	B,
	3196.7	11.5	Sg,	3199.7	11.5	Pt,	3202.7	11.3	Su,	3204.6	10.3	Ya,
	3204.8	10.5	Br,	3219.8	9.5	M,	3220.7<	10.9	Sg.			
143417 V LIBRAE—												
	3169.7	10.9	B,	3188.7	12.3	B.						
144918 U BOOTIS—												
	3158.5	11.6	Gi,	3172.6	12.6	B,	3183.5	12.1	Gi,	3194.4	12.2	Gi,
	3204.6	12.2	Gd,	3224.7	11.5	M.						
150018 RT LIBRAE—												
	3173.7	9.8	Pt,	3199.7	12.4	Pt.						
150605 Y LIBRAE—												
	3173.7	12.1	Pt,	3179.6	12.2	L,	3191.7	12.8	B,	3194.6	12.8	B,
	3197.4	12.5	L.									

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1922—Continued.

Star	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.
151520 S LIBRAE—								
	3133.3	9.3 Ch,	3151.5	8.5 Ch,	3164.2	8.5 Ch,	3173.7	8.4 Pt,
	3179.6	8.4 L,	3198.4	8.8 L,	3199.8	8.8 Pt.		
151714 S SERPENTIS—								
	3160.4	12.5 L,	3164.8	12.6 Wf,	3168.5	12.6 L,	3174.8	12.5 Wf,
	3188.7	12.3 B,	3188.7	12.0 Wf,	3195.4	11.8 L,	3196.8	12.1 Wf,
	3204.8	12.0 Wf,	3217.8	11.8 Wf.				
151731 S CORONAE BOREALIS—								
	3132.2	9.8 Ch,	3139.2	9.9 Ch,	3160.7	10.5 Sg,	3162.2	10.1 Ch,
	3162.7	10.2 Mu,	3164.8	9.9 Wf,	3167.6	10.2 Y,	3168.7	<9.4 Sg,
	3168.7	10.4 M,	3171.0	10.3 Ym,	3173.7	10.3 Pt,	3174.8	10.4 Wf,
	3175.7	10.3 Su,	3177.8	11.0 Sg,	3181.6	10.0 B,	3188.8	10.7 Wf,
	3188.8	10.8 Br.	3190.6	11.0 Pc,	3191.7	<11.1 Mu,	3195.7	11.2 Sg,
	3196.8	11.0 Wf,	3197.8	11.5 M,	3199.8	11.2 Pt.	3202.7	<10.8 Su,
	3202.8	11.0 Br.	3204.6	11.8 Y,	3204.8	10.9 Wf,	3217.8	11.8 Wf,
	3220.7	10.5 Sg.						
151822 RS LIBRAE—								
	3179.6	7.8 L,	3195.7	7.4 B,	3198.4	8.0 L,	3206.6	8.5 O.
152714 RU LIBRAE—								
	3173.7	11.8 Pt,	3179.6	11.2 L,	3188.7	10.5 Sg,	3191.7	9.6 Mu,
	3195.7	9.1 B,	3196.7	9.2 Mu,	3196.7	9.0 Sg,	3198.4	9.1 L,
	3199.8	8.9 Pt,	3206.6	8.3 O,	3220.7	8.5 Sg.		
153215 W LIBRAE—								
	3176.8	<10.2 Sg,	3188.8	<10.2 Sg,	3196.7	<10.2 Sg,	3220.7	<10.2 Sg.
153378 S URSAE MINORIS—								
	3162.7	10.2 Mu,	3164.8	9.6 Wf,	3170.7	10.2 Pr,	3171.0	9.7 Ym,
	3173.0	9.5 Ym,	3173.7	9.0 Pt,	3173.7	10.3 Mi,	3174.8	9.6 Wf,
	3175.3	10.4 Ro,	3180.1	9.5 Ym,	3180.3	10.2 Ro,	3187.6	9.0 Ya,
	3187.8	8.6 Wf,	3188.8	8.8 Br,	3189.3	9.6 Ro,	3194.3	9.2 Ro,
	3194.8	8.5 Wf,	3197.8	9.1 M,	3198.0	9.0 Ym,	3199.8	8.6 Pt,
	3201.1	8.7 Ym,	3202.7	8.7 Su,	3204.8	8.5 Wf,	3206.1	8.6 Ym,
	3209.7	8.5 Br.	3216.4	8.6 Ro,	3216.8	8.4 Wf,	3221.6	8.2 Wl,
154428 R CORONAE BOREALIS—								
	3132.2	6.2 Ch,	3138.1	6.1 Kd,	3150.2	6.3 Ym,	3151.6	6.1 L,
	3152.1	6.3 Kd,	3153.3	6.3 Ym,	3153.4	6.2 L,	3153.8	6.0 Jb,
	3154.6	6.3 L,	3159.1	6.2 Kd,	3159.7	6.4 Mu,	3160.4	6.1 L,
	3160.7	6.3 Mu,	3161.6	6.4 Hj,	3161.8	6.3 Jb,	3162.2	6.2 Ch,
	3162.7	6.3 Mu,	3163.1	6.2 Kd,	3163.7	6.2 Mu,	3163.7	6.2 Sg,
	3164.8	6.1 Wf,	3164.8	6.2 Mu,	3165.2	6.1 Kd,	3165.7	6.2 Mu,
	3165.7	6.3 Su,	3165.8	6.0 Wf,	3166.6	6.3 Pc,	3166.7	6.1 Pt,
	3166.7	6.3 Su,	3166.8	6.1 Jb,	3167.7	6.2 Mu,	3167.8	6.2 Pt,
	3167.8	6.0 Wf,	3168.5	6.1 L,	3168.7	6.3 Su,	3168.7	6.2 Mu,
	3168.7	6.2 M,	3168.7	6.4 Hj,	3168.7	6.1 Wf,	3168.7	6.0 Sg,
	3168.8	6.1 Pt,	3169.6	6.0 Ya,	3169.8	6.1 Wf,	3170.3	6.1 L,
	3170.8	6.0 Wf,	3171.1	6.3 Ym,	3171.8	6.0 Wf,	3171.8	6.1 Mu,
	3172.0	6.1 Kd,	3172.6	6.4 Gi,	3172.8	6.0 Sg,	3172.8	6.3 Mu,
	3173.6	6.3 Pc,	3173.7	6.1 Mu,	3173.7	6.2 Pt,	3173.7	6.4 Hj,
	3173.8	6.1 Wf,	3173.8	6.3 M,	3173.8	6.1 Su,	3174.7	6.1 Mu,
	3174.7	6.2 Pt,	3174.8	6.1 Wf,	3175.6	6.1 Pc,	3175.6	6.2 Su,
	3175.6	6.3 Cd,	3175.7	6.1 Wf,	3175.7	6.1 Mu,	3176.5	6.9 Cl,
	3176.6	6.7 Y,	3176.8	6.1 Mu,	3176.8	6.0 Sg,	3177.6	6.2 L,
	3177.6	6.5 Cs,	3177.6	6.1 Hs,	3177.8	6.1 Wf,	3178.7	6.2 Pt,
	3178.8	6.2 Mu,	3179.3	6.0 Pe,	3179.6	6.2 L,	3180.1	6.3 Ym,
	3180.2	6.1 Kd,	3180.6	6.2 L,	3180.8	6.2 Pt,	3181.8	6.1 Pt,
	3182.7	6.3 Hj,	3182.8	6.1 Pt,	3183.6	6.1 Pt,	3183.6	6.2 O.
	3184.7	6.0 Br,	3184.8	6.0 Wf,	3185.7	6.0 Pt,	3185.7	6.1 Wf,
	3186.5	6.3 Cl,	3186.8	6.1 Pt,	3187.4	6.3 Dp,	3187.4	5.9 Pe,
	3187.4	6.3 Jp.	3187.8	6.1 Wf,	3187.8	6.2 Sg,	3188.0	6.5 Ym,
	3188.0	6.0 Kd,	3188.4	6.1 L,	3188.6	6.1 Pt,	3188.7	6.2 Jb,
	3189.3	6.2 Ro,	3189.6	6.0 Hu,	3189.7	6.1 Mu,	3189.7	6.4 Hj,
	3189.7	6.1 Pt,	3189.9	6.0 Wf,	3190.6	6.1 Pt,	3190.6	6.2 Pc,

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
154428 R CORONAE BOREALIS—Continued.												
	3190.7	6.0	Mu.	3191.7	6.2	Pt.	3191.7	6.0	Mu.	3192.5	6.1	Gi.
	3192.6	6.0	L.	3192.7	6.1	Br.	3194.3	6.5	Ro.	3194.4	6.2	L.
	3194.4	6.5	An.	3194.6	6.2	O.	3194.8	6.1	Wf.	3195.3	6.3	An.
	3195.4	6.2	L.	3195.6	6.0	Ya.	3195.7	6.1	Mu.	3195.7	6.0	Jb.
	3195.7	6.0	Sg.	3196.6	6.3	M.	3196.7	6.1	Br.	3196.7	6.2	Pt.
	3196.7	6.1	Mu.	3196.7	6.0	Pc.	3196.8	6.2	Wf.	3197.4	6.1	L.
	3197.4	6.2	Gi.	3197.7	6.1	Pt.	3197.7	6.0	To.	3197.7	6.1	Mu.
	3197.8	6.2	Hj.	3197.8	6.1	Wf.	3197.9	5.8	Ym.	3198.0	6.1	Ym.
	3198.4	6.2	L.	3198.7	6.0	To.	3199.0	6.2	Ym.	3199.3	6.1	L.
	3199.7	6.0	Mu.	3199.7	6.0	Sg.	3199.7	6.1	Pt.	3200.6	6.1	Pt.
	3200.7	6.1	Mu.	3201.1	6.1	Ym.	3201.7	6.1	Br.	3201.6	6.4	Ra.
	3201.7	6.0	Mu.	3201.8	6.0	Jb.	3201.8	6.3	Pt.	3201.8	6.1	Wf.
	3202.4	6.1	Gi.	3202.6	6.1	Pc.	3202.6	6.2	O.	3202.7	5.9	Jb.
	3202.7	6.1	Su.	3202.7	6.1	Mu.	3202.7	6.3	Pt.	3202.8	6.0	Hj.
	3203.6	6.2	Su.	3203.7	6.1	Hj.	3203.7	6.1	To.	3203.7	6.2	Jb.
	3203.7	6.3	M.	3203.7	6.7	Ra.	3203.8	6.3	Pt.	3203.8	6.1	Wf.
	3204.0	6.2	Ym.	3204.4	6.1	L.	3204.6	6.2	Pt.	3204.7	6.1	Su.
	3204.7	6.1	Mu.	3204.7	6.0	Sg.	3204.8	6.1	Wf.	3205.6	5.9	Pc.
	3205.6	6.0	Hu.	3205.6	6.2	O.	3205.7	6.2	Mu.	3205.7	6.0	Hj.
	3205.7	6.1	Su.	3205.8	6.1	Wf.	3205.8	6.2	Pt.	3206.4	6.1	L.
	3206.4	6.4	An.	3206.7	6.1	Su.	3206.8	6.0	Jb.	3207.8	6.1	Wf.
	3209.6	6.0	Pc.	3209.8	6.0	Wf.	3210.8	6.2	Pt.	3211.7	6.2	M.
	3216.8	6.0	Wf.	3217.6	6.3	Pt.	3217.8	6.1	Wf.	3218.6	6.2	Pt.
	3212.7	6.2	Pt.	3214.6	6.2	Pt.	3214.8	6.1	Wf.	3215.7	6.2	Sg.
	3218.6	6.2	Su.	3219.6	6.1	Su.	3220.6	6.2	Pt.	3220.6	6.1	Su.
	3220.7	6.0	Sg.	3221.6	6.2	Pt.	3221.7	6.3	Je.	3224.7	6.3	M.
	3224.8	6.2	Pt.	3225.7	6.2	Pt.	3228.7	6.5	Lc.			
154536 X CORONAE BOREALIS—												
	3164.8	10.5	Wf.	3174.8	9.8	Wf.	3181.6	9.2	B.	3188.8	9.1	Wf.
	3196.8	9.1	Wf.	3197.8	12.0	M.	3204.8	9.2	Wf.	3217.8	9.8	Wf.
	3225.7	9.8	Pt.									
154615 R SERPENTIS—												
	3133.2	7.1	Ch.	3137.2	7.3	Ch.	3161.7	8.2	Jb.	3162.2	7.5	Ch.
	3163.8	8.0	Sg.	3167.7	8.3	Jb.	3168.7	8.3	M.	3171.2	7.8	Ch.
	3171.7	8.3	Sg.	3173.7	8.2	Pt.	3187.4	8.8	Pc.	3188.8	8.8	Sg.
	3194.6	8.8	O.	3194.6	9.0	B.	3196.7	8.8	Sg.	3197.8	9.0	M.
	3199.8	9.1	Pt.	3202.8	8.8	Jb.	3205.6	8.9	O.			
154639 V CORONAE BOREALIS—												
	3164.8	9.7	Wf.	3168.7	9.8	M.	3174.7	9.8	Pt.	3174.8	9.7	Wf.
	3181.7	9.1	B.	3188.8	9.6	Br.	3188.8	9.4	Wf.	3196.8	9.4	Wf.
	3197.8	9.9	M.	3197.6	10.4	Hs.	3199.8	9.0	Pt.	3204.8	10.0	Br.
	3204.8	9.4	Wf.	3217.8	9.6	Wf.						
155018 RR LIBRAE—												
	3138.4<11.9	Ch.		3164.2<11.9	Ch.		3179.6	13.3	L.	3191.7	13.4	B.
	3197.4	13.1	L.	3218.6	11.2	B.	3220.6	11.1	Pt.			
155229 Z CORONAE BOREALIS—												
	3171.0	11.6	Ym.	3181.7	10.4	B.	3198.8	10.7	M.			
155823 RZ SCORPII—												
	3174.7	9.1	Pt.	3199.8	10.2	Pt.	3202.8	10.2	M.	3206.6	10.8	O.
160021 Z SCORPII—												
	3179.6	11.6	L.	3204.4	12.2	L.						
160118 R HERCULIS—												
	3133.3	10.9	Ch.	3162.2	9.4	Ch.	3163.7	9.4	Sg.	3166.6	9.3	Pc.
	3171.7	10.0	Sg.	3174.7	9.5	Pt.	3188.8	9.6	Sg.	3191.7	9.5	Mu.
	3196.7	9.5	Mu.	3196.7	9.7	Cd.	3197.8	9.7	M.	3199.8	9.7	Pt.
	3202.6	9.7	Pc.	3215.7	10.5	Sg.	3218.6	<8.6	Mc.			
160210 U SERPENTIS—												
	3166.6	13.2	Y.	3175.6<11.9	Pc.		3189.6	11.7	M.	3190.6<11.9	Pc.	
	3194.6	12.9	B.	3198.1	12.0	Ym.	3202.6	13.6	Y.	3204.6<11.6	Pw.	
	3204.8<11.4	Br.		3220.7	12.0	Pt.						

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
160221a X SCORPII—												
	3205.8	11.5	M.									
160625 RU HERCULIS—												
	3164.8	12.3	Wf,	3168.7	12.2	M,	3174.8	12.3	Wf,	3175.6	12.2	Pc,
	3188.8	12.2	Wf,	3194.7	13.1	B,	3196.8	12.6	Wf,	3204.8	12.8	Wf,
	3217.8	12.9	Wf,	3220.7	13.2	Pt,	3224.7	12.4	M.			
161122a R SCORPII—												
	3168.4	<13.0	Jp,	3168.4	<13.0	Dp,	3175.3	<13.0	Jp,	3175.3	<13.0	Dp,
	3189.6	12.2	M,	3202.7	11.4	Pt,	3204.6	10.6	Pw,	3217.7	10.6	M.
161122b S SCORPII—												
	3168.4	12.1	Jp,	3168.4	11.9	Dp,	3175.3	12.2	Jp,	3175.3	12.2	Dp,
	3189.6	13.0	M,	3202.7	13.5	Pt,	3217.7	<13.5	M.			
161122c T SCORPII—												
	3189.6	10.2	M,	3202.7	11.0	Pt,	3204.6	10.6	Pw,	3217.7	10.4	M.
161138 W CORONAE BOREALIS—												
	3164.8	11.1	Wf,	3166.6	11.1	Y,	3167.6	11.0	Pc,	3174.7	10.8	Pt,
	3174.8	10.8	Wf,	3188.8	9.7	Wf,	3188.8	9.9	Br,	3189.6	10.0	Cd,
	3196.8	9.5	Wf,	3202.6	8.8	Y,	3202.7	8.8	Pt,	3204.8	9.3	Wf,
	3205.6	8.8	Pc,	3205.8	8.4	M,	3215.6	8.2	B,	3217.8	8.8	Wf.
161607 W OPHIUCHI—												
	3138.4	9.6	Ch,	3151.4	9.6	Ch,	3162.2	10.3	Ch,	3168.6	10.7	L,
	3168.7	10.6	M,	3174.7	11.1	Pt,	3195.4	11.9	L,	3198.1	12.0	Ym,
	3202.7	12.2	Pt,	3204.6	11.8	Y.						
162112 V OPHIUCHI—												
	3138.4	10.0	Ch,	3162.2	11.0	Ch,	3174.7	11.0	Pt,	3196.7	9.5	M,
	3202.7	9.0	Pt,	3218.6	9.7	O.						
162119 U HERCULIS—												
	3117.6	8.0	Gi,	3133.3	8.6	Ch,	3159.4	9.0	Gi,	3162.2	9.4	Ch,
	3163.7	9.2	Sg,	3164.8	9.1	Wf,	3166.6	9.2	Pc,	3168.7	9.5	M,
	3174.7	9.4	Pt,	3174.8	9.2	Wf,	3175.7	9.3	Su,	3175.8	9.3	Sg,
	3183.5	9.6	Gi,	3187.4	10.6	Pe,	3188.8	9.4	Br,	3188.8	9.3	Wf,
	3191.7	9.9	Mu,	3195.7	10.0	Sg,	3196.6	9.8	M,	3196.7	9.7	Mu,
	3196.8	9.6	Wf,	3197.4	9.7	Gi,	3202.6	9.9	Pc,	3202.7	10.0	Pt,
	3202.7	10.9	Su,	3204.7	10.2	Sg,	3204.8	9.8	Wf,	3205.6	10.3	O,
	3206.6	9.8	Y,	3217.8	10.4	Wf,	3218.6	<9.3	Mc,	3220.7	10.8	Sg.
162319 Y SCORPII—												
	3172.6	<13.5	Gi,	3195.7	<12.2	B,	3196.5	<14.2	Gi.			
162807 SS HERCULIS—												
	3160.4	11.8	L,	3168.7	12.0	M,	3174.7	11.9	Pt,	3177.6	11.4	L,
	3188.9	10.3	Br,	3192.6	10.1	L,	3198.5	9.7	L,	3198.8	10.0	M,
	3202.7	9.5	Pt,	3205.6	9.7	O,	3206.6	9.8	Y,	3209.7	9.5	Br.
162815 T OPHIUCHI—												
	3174.7	10.0	Pt,	3179.6	10.4	L,	3196.8	10.8	Cd,	3202.7	10.6	Pt,
	3203.7	10.9	Cd,	3206.6	10.4	Y.						
162816 S OPHIUCHI—												
	3138.4	10.4	Ch,	3179.6	13.6	L,	3206.6	<12.5	Y.			
163137 W HERCULIS—												
	3133.3	9.4	Ch,	3147.2	8.6	Ch,	3162.2	8.4	Ch,	3166.6	8.5	Y,
	3166.6	8.6	Pc,	3168.7	8.7	M,	3170.2	8.4	Ch,	3174.7	8.2	Pt,
	3188.9	8.5	Br,	3196.6	8.5	M,	3202.6	8.5	Pc,	3202.7	8.4	Pt,
	3205.6	8.6	O,	3221.8	9.2	Je.						
163172 R URSAE MINORIS—												
	3168.7	10.4	M,	3197.8	10.5	M.						
163266 R DRACONIS—												
	3132.2	8.3	Ch,	3144.2	7.9	Ch,	3157.2	7.8	Ch,	3166.6	7.7	Pc,
	3168.7	7.8	M,	3170.2	7.8	Ch,	3173.6	8.2	Y,	3190.6	8.4	Pt,
	3196.7	9.0	M,	3202.7	9.1	Pc,	3202.7	8.9	Pt,	3204.6	9.6	Y,
	3209.8	9.5	Br.									
164055 S DRACONIS—												
	3168.7	8.8	M,	3196.6	8.4	M.						

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
164319 RR OPHIUCHI—												
	3195.4	<13.0	L,	3206.0	13.0	Y,	3218.6	11.8	O.			
164715 S HERCULIS—												
	3117.6	8.6	Gi,	3159.4	9.8	Gi,	3161.8	9.3	Jb,	3164.2	10.4	Ch,
	3167.8	9.4	Jb,	3168.7	10.1	M,	3174.7	10.4	Pt,	3183.5	10.6	Gi,
	3188.8	10.5	Jb,	3188.9	10.7	Br,	3195.8	10.9	Jb,	3197.4	11.2	Gi,
	3202.7	11.0	Pt,	3202.8	12.0	Br,	3203.6	10.9	O,	3203.8	10.5	Jb,
	3203.8	10.5	To,	3204.6	11.1	Pw,	3215.6	12.1	B,	3219.8	12.0	M.
165202 SS OPHIUCHI—												
	3206.6	12.8	Y,	3220.7	12.3	Pt.						
165631 RV HERCULIS—												
	3162.7	10.2	Mu,	3163.7	10.5	Sg,	3168.7	10.3	M,	3172.8	10.5	Sg,
	3174.7	10.0	Pt,	3191.7	10.0	Mu,	3194.8	10.2	Lv,	3195.7	10.4	Sg,
	3196.7	10.1	Mu,	3196.7	11.0	M,	3198.1	9.9	Ym,	3202.7	10.7	Pt,
	3204.7	10.8	Sg,	3205.6	10.7	O,	3206.8	11.0	Lv,	3219.8	12.1	Lv,
	3220.7	12.0	Sg.									
170215 R OPHIUCHI—												
	3135.4	9.3	Ch,	3151.4	9.8	Ch,	3197.7	11.8	Pc,	3217.7	12.4	M.
170627 RT HERCULIS—												
	3164.8	12.7	Wf,	3174.8	13.2	Wf,	3188.8	13.3	Wf,	3202.8	<12.2	Br,
	3196.8	14.0	Wf,	3204.8	14.0	Wf,	3218.8	14.1	Wf,	3224.7	<12.4	M.
171401 Z OPHIUCHI—												
	3117.7	7.9	Gi,	3168.4	9.4	Jp,	3168.4	9.5	Dp,	3172.6	9.4	Gi,
	3174.7	9.6	Pt,	3186.4	9.4	Jp,	3186.4	9.4	Dp,	3188.9	9.8	Br,
	3194.5	9.8	Gi,	3202.7	10.4	Pt,	3202.8	10.4	Br.			
171723 RS HERCULIS—												
	3164.8	8.3	Wf,	3168.4	8.1	Jp,	3168.4	8.2	Dp,	3174.7	8.0	Pt,
	3174.8	8.1	Wf,	3175.4	7.8	Jp,	3175.4	7.8	Dp,	3187.4	7.0	Jp,
	3187.4	7.0	Dp,	3188.8	7.8	Wf,	3191.7	7.8	Mu,	3196.7	8.0	M,
	3196.7	8.0	Mu,	3196.8	8.2	Wf,	3202.7	7.8	Pt,	3204.8	8.4	Wf,
	3205.6	8.3	O,	3206.6	8.1	Pw,	3209.8	8.0	Br,	3217.8	8.2	Wf.
172809 RU OPHIUCHI—												
	3168.4	13.0	Jp,	3168.4	12.9	Dp,	3174.7	12.3	Pt,	3187.4	11.5	Jp,
	3187.4	11.6	Dp,	3188.9	<10.9	Br,	3189.6	12.0	M,	3202.7	11.3	Pt,
	3202.8	11.3	M,	3206.6	9.8	Pw,	3206.6	11.0	O,	3209.8	9.7	Br,
	3218.6	10.4	O,	3219.8	9.7	M.						
173212 RT SERPENTIS—												
	3198.4	9.3	L.									
174406 RS OPHIUCHI—												
	3174.7	11.1	Pt,	3202.7	11.0	Pt.						
175111 RT OPHIUCHI—												
	3168.4	12.5	Jp,	3168.4	12.3	Dp,	3187.4	<11.8	Dp,	3198.7	<12.4	To.
175458a T DRACONIS—												
	3118.6	12.6	Gi,	3160.4	11.7	Gi,	3173.6	11.6	Y,	3189.7	11.8	M,
	3194.4	11.2	Gi,	3203.6	10.7	M,	3204.6	10.8	Y.			
175458b UY DRACONIS—												
	3173.6	11.4	Y,	3189.7	11.0	M,	3203.6	11.0	M,	3204.6	11.4	Y.
175519 RY HERCULIS—												
	3135.4	10.7	Ch,	3164.3	<11.7	Ch,	3174.7	13.3	Pt,	3175.4	13.2	Jp,
	3175.4	13.2	Dp,	3194.8	13.4	Lv,	3202.7	13.8	Pt,	3203.6	13.6	M,
	3206.8	13.6	Lv,	3219.8	13.7	Lv.						
175654 V DRACONIS—												
	3175.4	<13.4	Jp,	3175.4	<13.4	Dp.						
180531 T HERCULIS—												
	3164.3	9.4	Ch,	3167.7	9.2	Jb,	3168.6	9.1	L,	3168.7	9.2	M,
	3174.7	8.5	Pt,	3175.4	8.5	Jp,	3175.4	8.4	Dp,	3175.7	8.6	Su,
	3188.8	8.1	Jb,	3188.9	8.2	Br,	3189.6	8.3	Cd,	3191.7	7.9	Mu,
	3192.6	8.1	L,	3196.7	8.4	Mu,	3196.7	8.1	Pc,	3196.7	8.6	M,
	3197.8	8.2	To,	3198.5	8.1	L,	3202.7	8.2	Pt,	3203.6	8.8	O,
	3203.7	8.3	To,	3203.7	8.3	Jb,	3217.6	8.6	Cd.			

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
180565 W DRACONIS—												
	3167.7	12.0	Jb,	3174.7	11.7	Pt,	3175.4	11.8	Dp,	3175.4	11.7	Jp,
	3188.8	11.3	Jb,	3188.9	11.1	Br,	3195.7	11.2	Lv,	3195.8	11.1	Jb,
	3202.7	10.1	Pt,	3203.7	10.4	To,	3204.8	10.0	Br,	3219.8	10.0	Lv.
180666 X DRACONIS—												
	3175.4	<13.4	Jp,	3175.4	<13.4	Dp,	3188.9	11.2	Br,	3195.8	13.8	Lv,
	3203.7	<12.3	To,	3204.8	<11.2	Br,	3219.8	<13.5	Lv.			
180911 NOVA OPHIUCHI #4—												
	3194.5	12.1	Gi,	3195.6	12.1	L,	3202.7	12.6	Pt.			
181031 TV HERCULIS—												
	3180.6	<14.0	L,	3197.4	<14.0	L.						
181103 RY OPHIUCHI—												
	3127.6	10.6	Gi,	3164.9	12.8	Wf,	3172.6	13.3	Gi,	3174.9	13.5	Wf,
	3189.8	12.4	Wf,	3192.4	12.2	Gi,	3194.8	12.1	Lv,	3196.8	12.0	Wf,
	3202.4	11.3	Gi,	3202.8	11.0	Br,	3204.8	11.2	Wf,	3209.8	11.1	Lv,
	3217.8	9.8	Wf.									
181136 W LYRAE—												
	3163.7	<10.5	Hj,	3164.9	12.3	Wf,	3167.6	12.4	Y,	3168.6	12.6	L,
	3174.8	12.3	Wf,	3189.8	12.1	Wf,	3190.7	12.1	Pt,	3195.4	10.9	L,
	3196.8	11.1	Wf,	3197.8	10.7	M,	3202.6	10.0	Y,	3202.7	10.1	Pt,
	3202.7	10.5	Su,	3203.6	10.2	O,	3203.7	10.5	Hj,	3204.8	10.2	Wf.
	3204.8	10.2	Sg,	3206.7	9.9	Hj,	3217.8	9.1	Wf,	3220.8	9.5	Sg.
182224 SV HERCULIS—												
	3168.6	12.2	L,	3174.8	11.9	Pt,	3192.6	9.9	L,	3198.5	10.1	L,
	3202.7	9.9	Pt,	3205.6	10.0	O.						
182306 T SERPENTIS—												
	3173.8	11.6	M.									
183149 SV DRACONIS—												
	3167.6	13.0	Y,	3175.4	13.0	Jp,	3175.4	13.0	Dp,	3202.7	11.5	Y.
183225 RZ HERCULIS—												
	3170.7	11.0	Y,	3198.8	12.0	M,	3202.7	12.4	Y,	3202.7	11.8	Pt.
183308 X OPHIUCHI—												
	3177.6	6.9	L,	3190.7	6.8	Pt,	3199.6	7.3	L,	3202.7	7.3	Pt,
	3203.7	7.4	Cd,	3205.8	7.6	M.						
184134 RY LYRAE—												
	3173.8	10.5	M,	3190.7	10.5	Pt,	3198.8	10.8	M,	3202.7	11.1	Pt.
184205 R SCUTI—												
	3136.3	6.8	Kd,	3138.4	6.0	Ch,	3151.6	6.4	L,	3165.2	7.1	Kd,
	3167.9	6.5	Pt,	3168.6	7.0	L,	3168.8	6.6	Pt,	3172.6	6.7	Gi,
	3173.8	6.2	M,	3173.9	6.5	Pt,	3174.8	6.5	Pt,	3175.8	6.4	Pt,
	3177.6	6.2	L,	3178.6	6.0	Cd,	3179.6	6.0	L,	3180.8	6.0	Pt,
	3181.8	6.0	Pt,	3182.8	5.6	Hj,	3182.8	5.9	Pt,	3185.7	5.7	Pt,
	3186.8	5.6	Pt,	3190.7	5.8	Pt,	3191.7	5.5	Mu,	3192.5	5.7	Gi,
	3192.6	5.4	L,	3196.7	5.9	Pt,	3197.7	5.9	Pt,	3197.8	5.6	Hj,
	3199.6	5.3	L,	3199.7	5.9	Pt,	3201.1	5.0	Ym,	3201.8	5.8	Pt,
	3202.7	5.9	Pt.	3202.7	6.1	Su,	3202.8	4.8	M,	3202.8	5.5	Hj,
	3203.6	5.5	Gi,	3203.8	6.3	Cd,	3203.8	5.1	Hj,	3203.8	5.9	Pt,
	3204.7	6.0	Su,	3204.7	5.6	Pt,	3205.7	6.1	Su,	3205.8	5.8	Pt,
	3206.1	5.5	Ym,	3206.7	6.0	Su,	3208.8	5.8	Sg,	3210.8	5.6	Pt,
	3212.7	5.5	Pt,	3214.6	5.5	Pt,	3217.6	5.5	Pt.	3218.6	5.4	Pt,
	3218.6	5.6	Su,	3219.6	5.7	Su,	3220.6	5.9	Su,	3220.6	5.5	Pt,
	3220.8	5.8	Sg.	3224.7	5.0	M,	3224.8	5.5	Pt,	3225.7	5.3	Pt.
184243 RW LYRAE—												
	3203.7	<14.0	M.	3217.7	<14.0	M.						
184300 NOVA AQUILAE #3—												
	3118.7	9.8	Gi.	3142.5	9.4	Ch,	3153.4	9.8	Ym,	3167.9	10.0	Pt,
	3172.6	9.8	Gi,	3173.8	9.4	M,	3173.9	10.3	Pt,	3175.4	10.0	Jp,
	3175.4	10.2	Dp,	3180.8	10.3	Pt,	3190.7	9.8	Pt.	3196.5	10.0	Gi,
	3196.7	10.3	Pt,	3198.1	9.9	Ym,	3202.7	10.1	Pt.	3202.7	10.0	M,
	3205.8	10.1	Pt,	3216.4	10.0	Ro,	3220.7	9.9	Pt.	3224.7	10.1	M.

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1922—Continued.

Star	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.
184929 NOVA LYRAE #1—								
	3196.4<13.0 Gi.							
185032 RX LYRAE—								
	3202.7	12.2 Pt,	3203.7	12.3 M,	3217.7	11.8 M.		
1855?2a ST SAGITTARII—								
	3168.6	12.9 L,	3195.6<12.8 L.					
185634 Z LYRAE—								
	3188.9<11.5 Br,		3204.8<12.2 Br.					
185737 RT LYRAE—								
	3175.4	12.8 Jp,	3175.4	13.0 Dp,	3188.9<12.0 Br,		3204.8	10.4 Br.
190108 R AQUILAE—								
	3147.5	11.5 Ch,	3187.8	11.2 M,	3190.7	10.5 Pt,	3198.8	9.8 M,
	3202.7	8.9 Pt,	3220.6	7.0 O.				
190529a V LYRAE—								
	3168.8	9.0 Pt,	3170.7	8.8 Y,	3198.8	10.0 M,	3199.8	9.4 Pt,
	3202.6	9.2 Y,	3218.6	10.0 Y.				
190907 TY AQUILAE—								
	3167.8	10.2 Pt,	3199.8	10.4 Pt,	3202.9	11.0 Br.		
190925 S LYRAE—								
	3167.8	11.7 Pt,	3168.6	12.3 L,	3173.8	10.9 M,	3192.6	12.0 L,
	3194.8	11.9 Lv,	3198.8	12.0 M,	3199.6	11.9 L,	3199.8	12.0 Pt,
	3209.8	12.2 Lv.						
190926 X LYRAE—								
	3167.8	8.8 Pt,	3173.8	9.4 M,	3198.8	9.0 M,	3199.8	8.5 Pt.
190933a RS LYRAE—								
	3202.8<11.3 Br,		3209.8<13.7 Lv.					
190941 RU LYRAE—								
	3178.4<13.0 Jp,		3178.4<13.0 Dp.					
190967 U DRACONIS—								
	3167.8	12.6 Pt,	3177.7	12.8 Mi,	3202.7	13.4 Pt.		
191007 W AQUILAE—								
	3202.9<11.8 Br.							
191019 R SAGITTARII—								
	3167.8	8.7 Pt,	3202.7	7.2 Pt.				
191033 RY SAGITTARII—								
	3151.5	10.2 Ch,	3167.8<10.0 Pt,		3168.6 <9.2 L,		3173.9<11.0 Pt,	
	3175.8<10.0 Pt,		3181.8<10.0 Pt,		3182.8<10.0 Pt,		3195.6<12.0 L,	
	3197.7<10.0 Pt,		3202.7<10.0 Pt,		3203.8<11.0 Pt,		3205.8<11.0 Pt.	
191319 S SAGITTARII—								
	3167.8	10.6 Pt,	3194.6	12.1 Gi,	3202.7	12.5 Pt.		
191321 Z SAGITTARII—								
	3194.6<13.9 Gi.							
191350 TZ CYGNI—								
	3167.8	11.0 Pt,	3173.6	11.0 Y,	3178.4	10.7 Jp,	3178.4	10.9 Dp,
	3196.7	10.9 M,	3202.6	10.0 Y,	3202.7	10.3 Pt,	3218.6	10.9 Wl.
191637 U LYRAE—								
	3167.9	11.5 Pt,	3198.8	10.8 M,	3202.8	11.4 Pt.		
192928 TY CYGNI—								
	3173.8<11.9 M,		3203.7	13.5 M,	3218.6<13.0 Wl.			
193311 RT AQUILAE—								
	3202.8<11.7 Br.							
193449 R CYGNI—								
	3135.5	9.4 Ch,	3164.3	7.4 Ch,	3167.9	7.3 Pt,	3173.7	7.4 Hj,
	3173.8	6.0 M,	3175.7	7.7 Hj,	3178.4	6.7 Jp,	3178.4	6.9 Dp,
	3180.7	7.8 Hj,	3188.7	6.7 Pc,	3189.0	6.6 Br,	3189.7	7.6 Hj,
	3191.7	6.7 Mu,	3195.8	6.6 Lv,	3196.7	7.8 Hj,	3196.7	6.8 Mu,
	3196.7	8.0 M,	3202.8	7.0 Pt,	3203.7	8.2 Hj,	3204.6	7.8 O,
	3205.6	7.5 Pc,	3205.7	8.0 Su,	3205.8	8.3 Hj,	3218.6	7.5 O.
193509 RV AQUILAE—								
	3167.9	8.5 Pt,	3178.4	8.3 Jp,	3178.4	8.4 Dp,	3187.4	8.1 Jp,
	3187.4	8.0 Dp,	3202.8	9.6 Br,	3202.8	9.8 Pt,	3220.6	10.7 O.

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
193732 TT CYGNI—												
	3211.7	8.0	M.									
194048 RT CYGNI—												
	3117.7	8.0	Gi,	3135.5	8.7	Ch,	3164.3	10.7	Ch,	3167.9	10 6	Pt,
	3173.7	<10.8	Hj,	3173.8	11.0	M,	3175.7	11.0	Hj,	3182.7	11.0	Hj,
	3183.6	11.3	Gi,	3191.7	9.8	Mu,	3196.7	9.0	Mu,	3196.7	<10.0	Hj,
	3197.4	11.1	Gi,	3202.8	11.2	Br,	3202.8	11.0	Pt,	3203.7	11.0	Hj,
	3204.6	10.0	O,	3205.7	9.5	Su,	3205.8	10.9	Hj,	3206.7	10.7	Hj,
	3217.7	9.8	M.									
194348 TU CYGNI—												
	3173.8	<12.4	M,	3178.4	<12.7	Jp,	3178.4	<12.7	Dp,	3195.8	12 6	Lv,
	3202.8	<11.7	Br,	3202.8	12.2	Pt,	3203.7	11.9	M,	3204.6	12.1	O,
	3209.7	11.6	Pc,	3217.7	10.9	M.						
194604 X AQUILAE—												
	3164.9	11.3	Wf,	3167.9	11.6	Pt,	3173.8	12.0	M,	3174.9	11.6	Wf,
	3189.8	12.0	Wf,	3196.8	12.4	Wf,	3202.8	12.5	Pt,	3203.7	12 7	M,
	3204.8	12.6	Wf.									
194632 χ CYGNI—												
	3175.7	<10.2	Hj,	3187.4	11.0	Pe,	3192.0	<11.9	Ym,	3199.1	11.6	Ym,
	3202.8	11.2	Br,	3202.8	11.5	Pt,	3203.7	10.8	Su,	3203.7	11.0	M,
	3218.7	<10.0	Lc,	3220.6	11.1	O,	3228.7	<10.2	Lc.			
195116 S SAGITTAE—												
	3201.7	5.8	Mu.									
195202 RR AQUILAE—												
	3187.4	9.1	Jp,	3187.4	9.0	Dp,	3202.8	9.4	Pt,	3224.7	9.2	M.
195308 RS AQUILAE—												
	3202.9	<11.7	Br,	3224.7	12.0	M.						
195653 NOVA CYGNI #3—												
	3118.7	10.2	Gi,	3150.4	9 8	Ym,	3166.7	10.0	Pt,	3167.9	10.0	Pt,
	3171.1	10.1	Ym,	3172.5	10.4	Gi,	3173.7	9.6	Pt,	3175.8	9.9	Pt,
	3180.8	10.3	Pt,	3182.8	10.3	Pt,	3185.7	10.1	Pt,	3187.4	10.8	Jp,
	3187.4	10.7	Dp,	3188.7	10.3	Pt,	3189.7	10.3	Pt,	3192.1	9.8	Ym,
	3196.4	10.6	Gi,	3196.7	10.2	Pt,	3199.7	10.2	Pt,	3201.8	10.0	Pt,
	3205.8	10.1	Pt,	3206.1	10.0	Ym,	3212.7	10.3	Pt,	3216.4	10.4	Ro,
	3217.6	10.2	Pt,	3218.6	10.0	Wf.						
195849 Z CYGNI—												
	3117.7	<14.4	Gi,	3164.9	12.5	Wf,	3167.9	12.4	Pt,	3172.5	11.4	Gi,
	3173.8	11.2	M,	3174.9	11.5	Wf,	3187.5	9.3	Jp,	3187.5	9.1	Dp,
	3189.8	9.1	Wf,	3194.6	9.3	Gi,	3196.7	9.8	M,	3196.7	9.8	Mu,
	3196.8	9.3	Wf,	3202.8	9.0	Pt,	3204.4	9.1	Gi,	3204.8	8.8	Wf,
	3218.6	9.8	O.									
200?:2 SY AQUILAE—												
	3173.8	10.6	M,	3173.9	10 7	Pt.	3177.6	10.6	L,	3196.7	11.5	M,
	3202.8	11.6	Pt,	3202.9	11.5	Br.						
200357 S CYGNI—												
	3173.8	10 8	M,	3173.9	10.8	Pt,	3190.7	11.8	Pc,	3202.8	<12.2	Br,
	3202.8	12.9	Pt,	3203.7	13.6	M.						
200514 R CAPRICORNI—												
	3196.6	9.8	Gi.									
200647 SV CYGNI—												
	3191.7	9.0	Mu,	3196.7	9.0	Mu.						
200715a S AQUILAE—												
	3127.7	9.2	Gi,	3164.9	9.4	Wf,	3173.8	9.1	M,	3173.9	9.4	Pt,
	3174.9	9.4	Wf,	3189.8	9.1	Wf,	3192.5	9.3	Gi,	3193.7	9.6	M,
	3196.8	9.4	Wf,	3203.5	9.8	Gi,	3204.6	10.3	Pt,	3204 8	9.6	Wf.
200715b RW AQUILAE—												
	3173.8	8.8	M,	3196.7	8.8	M.						
200747 RX CYGNI—												
	3191.7	7.8	Mu,	3196.7	7.8	Mu.						
200812 RU AQUILAE—												
	3205.8	10.2	M,	3220.6	10.5	O.						

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
200822 W CAPRICORNI—												
	3205.8	<11.1	M.									
200906 Z AQUILAE—												
	3173.8	9.8	M,	3173.9	9.3	Pt,	3192.6	10.4	Gi,	3203.6	12.2	Gi,
	3204.7	12.5	Pt,	3205.8	11.2	M.						
200916 R SAGITTAE—												
	3173.8	9.1	M,	3196.7	10.4	M.						
200938 RS CYGNI—												
	3137.5	8.6	Ch,	3173.9	7.8	Pt,	3177.6	8.2	L,	3187.8	9.0	M,
	3196.7	8.8	M,	3196.7	8.8	Mu,	3199.6	8.3	L,	3204.7	7.8	Pt.
	3212.7	8.9	M.									
201008 R DELPHINI—												
	3177.6	11.3	L,	3202.8	9.2	M,	3202.9	8.8	Br,	3220.7	8.0	Pt.
201121 RS CAPRICORNI—												
	3205.8	7.0	M.									
201130 SX CYGNI—												
	3187.8	11.5	M,	3202.7	11.4	Y,	3203.7	11.2	M,	3221.8	11.6	M.
201437a P CYGNI—												
	3137.5	4.8	Ch.									
201437b WX CYGNI—												
	3187.8	10.4	M,	3190.7	10.8	Pt,	3196.7	10.4	Mu,	3202.8	10.5	Br,
	3204.7	10.5	Pt,	3221.8	11.0	M.						
201647 U CYGNI—												
	3127.7	7.4	Gi,	3172.5	7.3	Gi,	3173.8	7.0	M,	3175.8	7.0	Pt,
	3188.8	6.7	Jb,	3191.7	7.4	Mu,	3195.8	6.9	Jb,	3196.4	7.6	Gi,
	3196.7	7.6	Mu,	3202.8	7.3	Jb,	3203.8	7.3	Jb,	3203.8	7.2	To,
	3204.7	7.5	Pt,	3209.8	7.8	Br,	3216.4	7.5	Ro,	3218.6	7.9	Wl,
	3218.7	7.7	Lc,	3221.8	7.0	M,	3228.7	7.9	Lc.			
202539 RW CYGNI—												
	3173.8	8.6	M,	3196.7	9.0	M,	3212.7	9.1	M,	3221.8	8.8	M.
202622 RU CAPRICORNI—												
	3196.6	12.8	Gi.									
202817 Z DELPHINI—												
	3175.8	9.0	Pt,	3203.8	9.8	M,	3204.7	10.1	Pt.			
202946 SZ CYGNI—												
	3168.8	9.4	Pt,	3173.9	9.6	Pt,	3181.8	8.8	Pt,	3182.8	9.6	M,
	3190.7	9.9	Pt,	3196.7	8.8	Pt,	3196.8	9.2	M,	3202.8	9.5	Pt,
	3204.7	10.5	Pt,	3218.6	9.5	Pt,	3221.8	9.8	M.			
202954 ST CYGNI—												
	3175.8	11.5	Pt,	3182.8	11.4	M,	3202.9	11.5	Br,	3203.7	11.6	M,
	3220.6	12.5	Pt.									
203226 V VULPECULAE—												
	3175.8	8.7	Pt,	3182.8	8.8	M,	3196.7	8.7	M,	3220.6	9.0	Pt.
203611 Y DELPHINI—												
	3202.9	<11.7	Br.									
203816 S DELPHINI—												
	3182.8	10.4	M,	3204.8	10.5	Br,	3211.8	10.7	M.			
203847 V CYGNI—												
	3117.7	9.6	Gi,	3137.5	<10.4	Ch,	3172.5	9.8	Gi,	3173.8	10.8	M,
	3190.7	11.3	Pc,	3196.4	10.3	Gi,	3202.9	11.0	Br,	3203.7	11.5	M.
203905 Y AQUARII—												
	3202.9	<11.9	Br,	3205.8	<12.4	M,	3225.7	11.0	Pt.			
204016 T DELPHINI—												
	3164.9	13.9	Wf,	3174.9	14.2	Wf,	3182.8	<12.4	M,	3189.8	<14.0	Wf,
	3196.9	14.3	Wf,	3202.9	<12.0	Br,	3203.7	<14.0	M,	3204.9	14.1	Wf,
	3225.7	14.5	Pt.									
204104 W AQUARII—												
	3168.6	9.8	L,	3192.6	10.2	Gi,	3199.6	10.4	L,	3202.6	10.3	Gi,
	3202.9	10.3	Br.									
204215 U CAPRICORNI—												
	3196.6	<14.0	Gi.									

VARIABLE STAR OBSERVATIONS. April 20 to June 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
204318 V DELPHINI—												
	3192.5	<13.9	Gi,	3202.8	13.0	M.						
204405 T AQUARII—												
	3147.5	9.1	Ch,	3181.8	8.0	Pt,	3205.8	9.0	M,	3225.7	10.7	Pt.
204846 RZ CYGNI—												
	3118.7	11.6	Gi,	3172.5	11.6	Gi,	3192.4	11.5	Gi,	3202.4	11.5	Gi,
	3203.7	12.7	M,	3204.9	<11.9	Br,	3225.7	12.9	Pt.			
205017 X DELPHINI—												
	3204.9	<11.4	Br,	3224.7	11.3	M,	3225.7	11.0	Pt.			
205030a UX CYGNI—												
	3196.7	11.5	M.									
205923 R VULPECULAE—												
	3175.8	8.5	Pt,	3182.8	7.8	M,	3183.6	8.6	Gi,	3194.6	8.9	Gi,
	3196.7	9.0	M,	3203.8	9.3	Hj,	3225.7	11.3	Pt.			
210124 V CAPRICORNII—												
	3196.6	<12.5	Gi.									
210129 TW CYGNI—												
	3182.8	<12.4	M,	3202.7	<13.0	Y.						
210221 X CAPRICORNI—												
	3196.6	<12.7	Gi.									
210382 X CEPHEI—												
	3173.6	<13.4	Y,	3197.6	<13.8	Pc,	3202.8	<12.1	Br.			
210504 RS AQUARII—												
	3195.6	12.1	L,	3204.9	11.3	Br.						
210812 R EQUULEI—												
	3225.7	12.8	Pt.									
210868 T CEPHEI—												
	3137.4	7.5	Ch,	3151.6	6.2	L,	3159.7	7.0	Mu,	3160.7	6.9	Mu,
	3162.7	6.9	Mu,	3163.7	6.9	Mu,	3164.8	6.8	Mu,	3165.7	6.8	Mu,
	3167.7	6.7	Mu,	3168.7	6.7	Mu,	3170.4	6.1	L,	3171.8	6.7	Mu,
	3172.8	6.5	Mu,	3173.7	6.3	Mu,	3174.7	6.1	Mu,	3175.7	6.0	Mu,
	3175.8	6.1	Pt,	3176.8	6.0	Mu,	3178.8	5.9	Mu,	3189.7	5.8	Mu,
	3190.7	5.9	Mu,	3191.7	5.8	Mu,	3194.4	5.8	L,	3195.7	5.9	Mu,
	3197.7	5.9	Mu,	3199.7	5.8	Mu,	3200.7	6.0	Mu,	3201.7	6.1	Mu,
	3201.8	6.1	Pt,	3202.7	6.3	Mu,	3205.7	6.4	Mu,	3205.8	6.0	M,
	3206.4	6.1	L,	3209.8	6.5	Br.						
211614 X PEGASI—												
	3175.8	9.2	Pt,	3194.6	10.1	Gi,	3201.8	11.0	Pt.	3204.9	11.3	Br,
213244 W CYGNI—												
	3150.3	6.3	Ym,	3153.3	6.6	Ym,	3165.2	6.5	Kd,	3168.6	5.9	L,
	3192.6	5.7	L,	3195.3	6.4	An,	3199.6	5.6	L,	3201.1	5.8	Ym,
	3205.1	5.7	Ym,	3206.4	5.8	L,	3206.4	6.3	An.			
213678 S CEPHEI—												
	3160.4	8.4	Gi,	3175.8	8.0	Pt,	3194.5	8.5	Gi,	3201.8	8.3	Pt,
	3202.8	8.5	Br,	3224.7	8.8	M.						
213753 RU CYGNI—												
	3187.8	8.4	M,	3211.7	8.2	M,	3220.7	8.5	Pt.			
213843 SS CYGNI—												
	3019.9	9.2	Jk,	3117.7	11.3	Gi,	3118.7	11.3	Gi,	3127.6	11.6	Gi,
	3135.4	9.7	Ch,	3137.4	8.3	Ch,	3142.5	8.9	Ch,	3147.4	11.6	Ch,
	3150.3	<10.9	Ym,	3151.6	11.4	L,	3153.3	11.3	Ym,	3154.6	11.5	L.
	3158.5	11.5	Gi,	3164.9	11.8	Wf,	3165.9	11.9	Wf,	3167.9	12.0	Wf,
	3167.9	11.8	Pt,	3168.5	12.0	Jp,	3168.5	12.0	Dp,	3168.6	11.8	L,
	3168.8	12.0	Wf,	3168.8	11.9	Pt,	3169.8	11.8	Wf,	3170.8	12.0	Wf,
	3172.5	11.8	Gi,	3173.9	10.9	Wf,	3173.9	10.5	Pt,	3174.4	9.1	Jp,
	3174.4	9.0	Dp,	3174.7	8.4	Pt,	3174.9	8.7	Wf,	3175.4	9.1	Jp,
	3175.4	9.0	Dp,	3175.8	8.7	Pt,	3175.8	8.4	Wf,	3177.6	8.9	L,
	3177.8	8.8	Wf,	3178.5	9.2	Jp,	3178.5	9.2	Dp,	3179.6	9.0	L,
	3180.8	9.6	Pt,	3180.8	9.0	Hj,	3181.8	10.2	Pt.	3182.8	10.6	Hj,
	3182.8	10.2	M,	3182.8	10.3	Pt,	3183.6	11.0	Gi.	3184.8	11.5	Wf,
	3185.4	11.9	Jp,	3185.4	11.9	Dp,	3186.4	11.9	Jp.	3186.4	11.9	Dp,

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
213843 SS CYGNI—Continued.												
	3187.5	11.8	Jp,	3187.5	11.7	Dp,	3187.8	11.5	M,	3187.8	11.6	Wf,
	3188.4	12.0	Jp,	3188.4	12.0	Dp,	3188.7	11.9	Pt,	3188.7	11.8	Pc,
	3188.8	11.8	Wf,	3188.9	<11.3	Br,	3189.7	11.9	Pt,	3189.7	12.0	M,
	3189.8	12.0	Wf,	3189.8	<9.6	Hj,	3190.7	11.9	Pt,	3190.7	11.9	Pc,
	3191.4	12.1	Jp,	3191.4	12.1	Dp,	3191.7	11.9	Pc,	3192.5	11.8	Gi,
	3192.6	11.7	L,	3194.6	11.8	Gi,	3194.8	12.0	Wf,	3195.4	11.9	L,
	3195.4	12.0	An,	3195.7	12.0	Wf,	3196.4	11.8	Gi,	3196.7	11.9	Pc,
	3196.7	11.8	Pt,	3196.9	12.0	Wf,	3197.4	11.9	Gi,	3197.6	11.9	Pc,
	3197.7	11.8	Pt,	3197.8	12.0	M,	3197.8	<10.9	Hj,	3197.8	11.9	Wf,
	3198.5	11.3	L,	3198.6	11.8	Gi,	3199.4	11.8	Gi,	3199.5	11.5	L,
	3199.7	11.8	Pt,	3200.6	11.8	Pt,	3201.1	12.1	Ym,	3201.8	11.8	Pt,
	3201.8	11.9	Wf,	3202.4	11.9	Gi,	3202.7	<11.0	Pc,	3202.8	<11.3	Hj,
	3202.8	11.7	Pt,	3202.8	11.9	Jb,	3202.9	11.8	Br,	3203.5	11.8	Gi,
	3203.7	11.8	To,	3203.7	<11.3	Hj,	3203.8	12.0	Wf,	3203.8	11.9	Pt,
	3203.8	11.8	Jb,	3204.4	11.7	L,	3204.4	11.8	Gi,	3204.7	11.8	Pt,
	3204.8	11.9	Wf,	3204.9	11.8	Br,	3205.1	12.1	Ym,	3205.7	<11.0	Pc,
	3205.8	<11.3	Hj,	3205.8	11.8	Pt,	3205.8	12.0	Wf,	3206.1	12.2	Ym,
	3206.4	11.7	L,	3206.4	11.9	An,	3206.5	11.9	Gi,	3206.7	<11.3	Hj,
	3206.8	11.6	M,	3207.8	12.0	Wf,	3209.6	11.0	Pc,	3209.8	12.0	Wf,
	3210.6	12.1	Wl,	3211.7	12.0	M,	3212.7	11.8	Pt,	3213.6	12.1	Wl,
	3214.6	<11.0	Pt,	3214.7	12.0	Wf,	3215.7	12.0	Wf,	3216.6	12.1	Wl,
	3216.8	11.9	Wf,	3217.6	12.1	Wl,	3217.6	11.7	Pt,	3217.7	12.0	M,
	3217.8	12.1	Wf,	3218.6	12.0	Wl,	3218.6	<11.3	O,	3218.6	11.8	Pt,
	3218.8	12.0	Wf,	3219.6	12.0	Wl,	3220.6	11.9	Wl,	3220.6	12.0	O,
	3220.6	11.8	Pt,	3220.8	12.0	M,	3221.6	11.9	Wl,	3221.7	11.6	Je,
	3221.8	12.0	M,	3224.6	12.0	M,	3225.7	11.8	Pt.			
213937 RV CYGNI—												
	3175.8	6.5	Pt,	3182.8	7.8	M,	3197.8	8.0	M,	3201.8	6.6	Pt,
	3212.7	7.5	M.									
214024 RR PEGASI—												
	3181.9	12.6	Pt,	3201.8	13.0	Pt,	3204.9	<12.0	Br.			
215605 Y PEGASI—												
	3204.9	<11.5	Br.									
215934 RT PEGASI—												
	3204.9	10.4	Br.									
220133b RZ PEGASI—												
	3204.9	<11.8	Br.									
220412 T PEGASI—												
	3177.6	10.3	L,	3197.6	9.4	Gi,	3204.9	9.2	Br.			
220613 Y PEGASI—												
	3197.6	10.5	Gi,	3204.9	11.2	Br.						
220714 RS PEGASI—												
	3197.6	12.9	Gi,	3204.9	<11.3	Br.						
222439 S LACERTAE—												
	3168.6	8.1	L,	3192.5	8.1	Gi,	3199.6	8.3	L,	3202.6	8.6	Gi,
	3202.8	8.5	Pt.									
223841 R LACERTAE—												
	3177.6	11.0	L,	3192.5	10.1	Gi,	3202.6	9.2	Gi.			
225914 RW PEGASI—												
	3202.8	10.5	M.									
230110 R PEGASI—												
	3201.8	9.6	Pt.									
230759 V CASSIOPEIAE—												
	3127.3	8.8	Gi,	3160.3	10.5	Gi,	3181.9	11.9	Pt,	3192.6	11.9	Gi,
	3202.8	12.7	Pt,	3203.6	12.4	Gi.						
231425 W PEGASI—												
	3177.6	10.0	L.									
231508 S PEGASI—												
	3202.8	10.3	Pt.									
233335 ST ANDROMEDAE—												
	3164.9	9.5	Wf.	3173.9	10.0	Pt,	3174.9	9.7	Wf,	3189.9	9.8	Wf,

VARIABLE STAR OBSERVATIONS. April 20 to June 20, 1922—Continued.

Star	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.
233335 ST ANDROMEDAE—Continued.								
	3196.9	10.2 Wf,	3201.2	10.2 Ym,	3202.8	10.2 Pt,	3204.9	10.3 Wf,
	3204.9	10.0 Br,	3205.8	10.4 M.				
233956 Z CASSIOPEIAE—								
	3164.9	13.5 Wf,	3174.9	13.7 Wf,	3189.9≤	13.4 Wf,	3196.9<	13.4 Wf,
	3204.8	14.2 Wf.						
235053 RR CASSIOPEIAE—								
	3131.4	10.8 Gi,	3160.3	11.4 Gi,	3192.6	12.7 Gi,	3203.6	13.0 Gi.
235350 R CASSIOPEIAE—								
	3131.3	10.2 Gi,	3197.6	11.9 Gi.				
235525 Z PEGASI—								
	3181.9	9.1 Pt,	3202.8	10.3 Pt.				
235855 Y CASSIOPEIAE—								
	3131.4	10.5 Gi,	3160.3	11.8 Gi,	3198.6	12.2 Gi.		
235939 SV ANDROMEDAE—								
	3202.8	11.9 Pt.						

Total Observations: 2,863. Stars Observed: 307. Observers: 47.

Mrs. D. H. Leavens, Norwich, Conn.
Peter Marcus, New York, N. Y.
Prof. D. H. Markham, Fayetteville, Ark.
Charles A. Pease, Monrovia, Cal.
W. H. Riggs, Constantinople, Turkey.
J. B. Sargent, Lake Placid, N. Y.
R. H. Sellars, Montclair, N. J.

Mr. J. F. Porter, Chicago, Ill., has been elected to Life membership, and Mr. Dean Potter who has long been an active member has changed his membership from Active to Life.

Mr. C. W. Elmer has placed his 6-inch reflector at the disposal of the Association. Application for the use of this and other glasses should be made to Prof. Anne Young, Mt. Holyoke College, So. Hadley, Mass. Communications with regard to the Circulating Library should be addressed to Mr. C. Y. McAteer, 534 So. Winbiddle Av., Pittsburgh, Pa. Mr. D. F. Brocchi of Seattle has been appointed a member of the Chart Committee. Copies of the 1921 Reprint, of the Circulating Library Catalogue and of the Supplement to the 2nd Slide Catalogue should soon be distributed to all. For the latter two we are indebted to the generosity of Mr. C. E. Barns.

In the following list of contributors to this double report, the aperture of the telescope which each observer uses, expressed approximately in inches, is indicated by a numeral following the observer's name; e. g., Bouton, "B" 6 indicates that Rev. Bouton of St. Petersburg, Fla., observes with a six inch refractor. In case the instrument is a reflector this numeral is followed by "r" as in the case of Waterfield "Wf" 12r. In some cases observers use more than one instrument, and they are cautioned to be very explicit in their reports which was used for each observation, although it will be impossible to indicate this in the printed reports.

The following observers contributed to this report: Ancarani "An" 5r, Bouton "B" 6, Brocchi "Br" 6, Miss Carson "Cs" 5, Chandler "Cd" 3, Chandra "Ch" 3, Clement "Cl" 4, Miss Cook "Ck" 7, Miss Farnsworth "Fn" 8, Ginori "Gi" 9, Godfrey "Gd" 8r, Miss Harding "Hg" 7, Miss Hawes "Hs" 5, Hoerl "Hj" 3, Hunter "Hu" 8, Jacobsen "Jb" 5, Miss Jenkins "Jk" 3, Jewell "Je" 15r, Miss Johnson "Jn" 7, Kanda "Kd" 2, Miss Kingman "Kg" 7,

Lacchini "L" 5, Lacy "Lc" 4, Leavenworth "Lv" 10, McAteer "M" 5, 13, Macaughey "Mc" 3, Miss Miller "Mi" 11, Mundt "Mu" 3, Olcott "O" 5, Dr. Paraskevopoulos "Jp" 16, Mrs. Paraskevopoulos "Dp" 16, Miss Parsons "Pr" 11, Peltier "Pt" 6, de Perrot "Pe" 4, Proctor "Pc" 12, Miss Quarles "Q" 7, Rabinowitz "Ra" 3, Rhorer "Ro" 5, Skaggs "Sg" 5, Suter "Su" 4, Townley "To" 5, Waldo "Wl" 9r, Waterfield "Wf" 12r, Watson "Pw" 6, Yalden "Ya" 4, Yamamoto "Ym" 7, and Miss Young "Y" 8.

HOWARD O. EATON, Recording Secretary.

GENERAL NOTES.

Death of Prof. J. C. Kapteyn.—Word has just been received that Prof. J. C. Kapteyn, the founder and director of the Astronomical Laboratory at Groningen, Holland, has died. We hope to publish a biographical sketch in a future number of POPULAR ASTRONOMY.

Professor Ambronn.—The retirement of Professor Ambronn, of the Observatory at Göttingen, has been announced. Dr. Meyermann, formerly director of the Observatory of Tsingtau, and subsequently a prisoner of war in the hands of the Japanese, has been appointed to succeed him.—*Science*, June 2.

Dr. F. C. Leonard, (Ph. D., Univ. of California, 1921) has been appointed Instructor in Astronomy in the southern department of the University of California at Los Angeles.

The International Astronomical Union Granted an Audience by the Pope.—On the 10th of May, at one thirty, the Pope granted to the members of the congress (about 150 in number) a solemn audience which took place in the vast Hall of the Consistory. Accompanied by the noble guard, by the honorary attendants of the order of Cloak and Sword, and by the officers on duty of the various armed pontifical corps, the Pope made his entrance into the Hall accompanied by his chief Chamberlin, Mons. Caccia-Dominioni.

The astronomers who were stationed along the wall of the room, were successively presented to the Pontiff by Professor Pio Emanuelli, of the Vatican Observatory, and for each one of them the father had words of interest for the studies in which they had specialized.

When the introduction was over, the holy Father presented to the astronomers a most noble discourse. After having given, with great and special kindness a greeting to so select a group of scholars, the Pope added that the science which the members of the congress professed is the loftiest and most sublime, the one that leads to the way of truth to which all ought to aspire.

The Pope then expressed the hope that from the way of truth, it might be granted to expect the return in this world of that true and universal peace, of that pacification of minds, which is his constant thought. And he observed that the men of science, more than the others may attain more easily, because of the loftiness of their studies, this pacification to which all ought to aspire, and he recommended to those present that in the study of the profound questions which are aroused in their minds, there should have been established this ideal, for

this is the will of God. As the star which shone at Bethlehem, so the present astronomical congress should be an augury of peace. The Pope added that the truly great admiration that he felt for the beauty of the universe, for this marvelous divine construction whose laws, grandure, and harmony the astronomers know, leads him reverently to the Creator of this marvelous edifice, to whom those present ought to be nearer than all those who have not the wings to succeed in understanding astronomical observations and studies.

In the name of the Creator of the Heavens, the Holy Father bestowed on all those present, on all absent persons dear to them, on all objects on which one desired it to be done, the Apostolic Benediction and voiced the hope that the common prayers would be heard.

Holmes Cowper Scholarship.—I am pleased to announce a scholarship in the Department of Astronomy at Drake University known as the Holmes-Cowper Scholarship.

This scholarship was given by Dean Holmes Cowper of the Drake University Conservatory of Music and has been awarded to P. C. Daniels, whose duties will consist in part of assisting on public nights in the Drake University Municipal Observatory.

The attendance is large. In fact, we are unable to accommodate all of the people who make application to visit the Observatory. The average number taken care of per week is about two hundred persons.

D. W. Morehouse.

Note on Red Dwarf Stars.—Hertzsprung has called special attention to the sameness in the color index of dwarf red stars throughout a range of several magnitudes in absolute brightness (M. W. Contr. 101, 1915, and elsewhere). To explain how a cooling star can lose more than 95 per cent of its light without growing redder, he suggests that these dwarf stars may have reached the stage at which the formation of relatively dark solid matter at the surface begins; and he further suggests that such stars should be tested for variability of light.

A measurable, continuous decrease in the light intensity of stars approaching extinction is, of course, not to be expected in an interval of twenty or thirty years. Irregular fluctuations, however, might be present. To test this possibility, the following dwarf stars have been studied on series of Harvard photographs, well distributed throughout the interval indicated in the last column. The absolute magnitudes and spectral types are taken from Mount Wilson Contribution 199. The plates were examined by Miss Wells. Variations, if present, must be small, since no evidence of them is found from this material.

R.A.1900 h m	Dec.1900 ° ′	Vis. Mag.	Proper Motion ″	Spectrum	Abs. Mag.	Plates Examined	Interval
0 12.7	+43 27	8.1	2.890	Ma	10.4	27	1898-1921
3 38.2	+68 21	9.2	0.30	K8	9.0	17	1891-1921
10 5.3	+49 58	6.8	1.451	K6	8.3	27	1898-1921
10 14.2	+20 22	9.2	0.490	Mdp	10.5	22	1890-1921
10 57.9	+36 38	7.6	4.779	Ma	10.5	26	1894-1921
13 40.7	+15 26	8.5	2.298	Mb	10.2	34	1891-1919
16 50.1	− 8 9	9.2	1.234	Md	10.1	22	1891-1920
17 37.0	+68 26	9.5	1.334	Mb	10.5	20	1900-1921
23 44.0	+ 1 52	8.7	1.393	Ma	10.1	26	1902-1921

Harvard College Observatory Bulletin 769.

Radial Velocities of 594 Stars.—Vol. II, No. 1, of the Publications of the Dominion Astrophysical Observatory, which has just come to hand, contains the results of measures of spectrograms for radial velocity of 594 stars, obtained in the course of systematic work with the 72-inch Reflector during the years 1918-1921. The work of observation, measurement and reduction was divided among four men, J. S. Plaskett, Director, W. E. Harper, R. K. Young and H. H. Plaskett. The working list consisted principally of stars of Boss's catalogue for which observations for radial velocity had not been previously obtained. After dividing this list with the Mt. Wilson Observatory there were 770 stars ranging in magnitude between the fifth and ninth. Fifty of these of the eighth magnitude and fainter were deferred for observation with lower dispersion, and in the course of the work 183 were found to be spectroscopic binaries or otherwise unusable, leaving 537 for the main catalogue of presumably constant radial velocities.

The individual results are given for the separate spectrograms of each star and the accordance is excellent for stars whose spectra are of the types showing well-defined lines. Each star received, as a rule, five or more observations. The probable errors range from ± 0.1 to ± 1.0 km for the mean velocity from several spectrograms, and between ± 0.2 and ± 2.5 km for a single plate, where the lines are sharply defined.

The largest velocity which we happen to notice in this catalogue is that of the star Boss 4350, R. A. $17^h\ 02^m1$, Dec. $+22°\ 13'$, visual magnitude 5.72, spectral type K2. The individual results for this star are

Date	Radial Velocity
1920 April 24.975	—96.9 km
May 6.953	—95.5
June 22.791	—94.4
July 3.763	—98.9
Aug. 3.712	—98.9
Aug. 30.650	—98.7
Mean	—97.2 ± 0.5

The Telescope.—By Louis Bell, consulting engineer. McGraw-Hill Book Co., Inc., Penn Terminal Building, 370 Seventh Avenue, New York. 285 pages. $3.00 post paid.

This is the best book on the telescope which we have seen. It is up to date, accurate, well planned and well illustrated. It takes up the development of the telescope from its inception to the present time, discusses optical glass and its working, the properties of objectives and mirrors, the various forms of mountings, eye-pieces and other accessories. A chapter is given on the testing and care of telescopes and another on various methods of housing the instrument. A brief appendix gives a few reasonable suggestions as to work which may be done by the amateur with a small telescope. The book is well worth the price asked, and should be in the hand of every amateur astronomer.

Astrophysik, Scheiner-Graff, Teubner-Leipzig, 556 pp. $3.50. This third edition of Scheiner's *Populaere Astrophysik* has been largely rewritten and brought up to date by Prof. K. Graff. It is not a technical work for astronomers only but a valuable work for the general scientific reader. So far as the reviewer knows it is the only work of its kind in any language which in any adequate way covers the field of astrophysics as it is today. The first third of the volume

deals with the methods of astrophysical research and the balance of the book is devoted to the results of investigations. The book is well written both as to style and balance between the various lines of work. It can be recommended as the best modern work of its kind.

Note on Ionized Calcium in β Aurigae.—The suggestion that occasional double stars, and possibly some single stars, move in gaseous envelopes has frequently been made to explain the appearance of stationary H and K lines of calcium in the spectra of binary stars of the first spectral type. (Lee, Ap. J. **37**, 1, 1913; Saha, Nature **107**, 488, 1921). Such an envelope of light gases would probably act in some cases as a resisting medium, a phenomenon that would be of much significance in the evolutionary development of a double star.

From Saha's theory of stellar spectra it appears unlikely that such a gaseous envelope could be easily detected for any element but calcium, for which the resonance lines of the ionized atoms are conspicuous and lie in the available part of stellar spectra. At the writer's request, Miss Maury has examined a large number of photographs of the spectrum of the close spectroscopic binary β Aurigae in order to see if evidence could be found of the dependence of calcium absorption on the condition of approach or recession of the light-emitting surface.

β Aurigae was the second spectroscopic binary discovered, being found by Miss Maury in 1889. The Harvard collection contains approximately six hundred photographs of the spectrum. About one half of the plates show the lines double. One component is slightly brighter than the other. The spectrum is given as A in the Henry Draper Catalogue, but is more advanced than Vega and Sirius.

A clear deduction from the present examination of more than 300 photographs is that, as previously suspected by Miss Maury, the bluer component of the doubled K line of calcium is diffuse, the redder component sharp, whichever star is approaching the observer. When the bright component is approaching the line is very noticeably wider than when it is receding, as well as much less clear. In other words, there is for both components a difference in the appearance of the spectral line for the front and back side of the surface. This effect cannot be clearly seen for any other metallic lines, which on the Harvard plates are relatively faint. The H line of calcium is not separated from the H_ϵ line of hydrogen, and all the hydrogen lines are too strong to permit a study of the doubling.

It is not clear why the following side of a revolving star should show sharper lines than the preceding side. That there is a difference (whatever its explanation) argues for the existence of an envelope of ionized calcium gas in the system of β Aurigae. Baker's spectroscopic elements indicate a nearly circular orbit; he finds a suggestion of a lengthening period (Alleg. Pub. **1**, 163, 1910).

Miss Maury has also examined the Harvard spectrum plates of ζ Ursae Majoris, which has the same type of spectrum, but a more eccentric orbit. The abnormality noted in the case of β Aurigae is not present in ζ Ursae Majoris. The period of the latter is 20.5 days; the period of the former is 3.96 days.

Evidence that, in some eclipsing stars, the preceding side of the components differs in brightness from the following side has been pointed out by Dugan and Stebbins. A difference in the sharpness of the spectral lines of the secondary component before and after conjunction, as noted by Adams and Joy for one or two eclipsing binaries, is also probably to be associated with this same phenomenon.

Harvard College Observatory Bulletin 767.

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